

Contract No. 951263

Report No. TE 20-67

THIRD QUARTERLY REPORT
SOLAR THERMIONIC
GENERATOR DEVELOPMENT

September 1966

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California Institute of Technology, sponsored by the
National Aeronautics and Space Administration under
Contract NAS7-100.**

Prepared for
Jet Propulsion Laboratory
Pasadena, California



INTRODUCTION

This document constitutes the Third Quarterly Report of the work being performed under Thermo Electron's Contract No. 951263 with the Jet Propulsion Laboratory.

The objectives of this program are twofold, and are to be reached under two task efforts; they are:

- I. To develop a converter of the design used under Task II of Contract No. 950671, which is capable of delivering a power output of 20 watts/cm² at one volt, with a minimum measured efficiency of 16%.
- II. To develop a prototype structure of a 14%-efficient, multi-converter generator capable of operation in cislunar space with a concentrator 9.5 ft in diameter, which uses the converters developed under Task I.

Task I centers on the iterative construction of 9 engineering models of a solar-energy thermionic converter. The aim of the first model is to partially duplicate the best converter developed under Task II of Contract No. 950671. The second and third are principally geared to the incorporation of a modification in the heat-transfer path of the collector-radiator structure to assure efficient and reliable heat transfer. The fourth and fifth are intended to effect a change in the materials of the convoluted emitter structure whereby the entire structure will be made of rhenium. The sixth and seventh converters will provide a study of two new collector materials, and the eighth will be a final prototype incorporating all the features found to improve performance in the course of the work. The



ninth prototype will duplicate the eighth except that the interelectrode spacing may be changed in order to make a performance comparison.

Task II involves a generator flux analysis, a shielding evaluation, and a mock-up environmental test based on a selected generator design. The analysis will determine the best number of converters to match the converter heat requirements to the available solar energy, the optimum cavity aperture size, the required adjustments of surface emissivity and absorptivity values to ensure even flux distribution, and the effects of changes in emitter temperature and heat input on flux distribution within the generator. The shielding test is primarily intended to verify design assumptions on shielding heat losses, and to select a preferred shield configuration. The mock-up environmental tests will be conducted to explore all areas of possible structural weakness to vibration, shock, acceleration and acoustical environments, and effect the design changes indicated.

This report covers progress for the period June 1, 1966 to September 3, 1966.



SUMMARY

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During the third quarter, the third and fourth thermionic converter engineering models, T-203B and T-204, were fabricated and tested. Both converters exhibited substantially better performance than the previous models. Converter T-204 was able to deliver an output of 29 amperes at 1.0 volt at 1724°C hohlraum temperature and in steady state, in spite of the lowered emitter temperature of 1961°K caused by the higher thermal resistance of a solid rhenium emitter.

The fabrication of T-204 included the test of an all-rhenium emitter structure which was successfully cycled through 10 fast thermal cycles to 1780°C at the hohlraum. Furthermore, chromium carbide and zirconium carbide were evaluated as possible alternate radiator coatings to chromium oxide, but both materials were found to have only 60% of the emissivity of chromium oxide.

No work under Task II was scheduled for this period, and none was performed.

Author



1.1 Fabrication of Converter T-203B

As mentioned in the previous quarterly report, the first attempts at the fabrication of this converter, identified by the serial numbers T-203 and T-203A, were not successful. Both prototypes leaked after outgassing at the palladium braze between the molybdenum collector and the niobium inner seal flange. The failure was found to be the result of improper flow of the palladium braze and excessive collector outgassing temperature. Consequently, the emitter structure of T-203A, consisting of the pressure-bonded electropolished and electro-etched rhenium sheet and its tantalum substrate, was salvaged, checked for flatness and used in the fabrication of T-203B. To avoid a repetition of the previous two failures, converter T-203B was assembled with a carefully selected collector subassembly with good braze flow, and its outgassing was first performed with a collector temperature of 660°C instead of 800°C. The outgassing time was approximately 24 hours and the vac-ion reading at the end of outgassing was 8×10^{-7} torr, hot, and 1×10^{-7} torr, cold. After the converter was charged with cesium, initial tests showed that it had a leak located at the final pinch-off. The converter was then opened at the location of the leak and placed in a vacuum furnace for 2 hours at 500°C to remove any traces of possible cesium compounds. A new tubulation was attached for outgassing, and the final outgassing was performed for 16 hours with a collector temperature of 627°C. The final pressure readings were 16 and 8×10^{-7} torr in the hot and cold conditions. The cesium distillation followed the usual schedule of 5 hours at 200°C.



The collector of this converter was chemically etched with a room-temperature solution of 50 parts H_2O , 20 parts HNO_3 , and 30 parts H_2SO_4 . This was the first time this modification had been used. The radiator fins were coated with the specified zirconium carbide coating that had been used for T-201 and T-202. Subsequent analysis showed, however, that the supplier of the coating material had substituted chromium carbide for zirconium carbide. Therefore, T-201, T-202 and T-203B have chromium carbide radiator coatings.

1.2 Fabrication and Test of All-Rhenium Emitter Structure

Two attempts were made at electron-beam welding a structure of the type of Design IV, Dwg. 555-1000 (Figure 1, First Quarterly Report), in which an outer seal flange of niobium is joined to an intermediate emitter support of rhenium by melting the edge of the niobium material and allowing it to wet the rhenium piece without melting it. The reason the rhenium is not allowed to melt and alloy with the niobium metal is that under such conditions it will form a brittle intermetallic, and the weld will crack upon cooling. In these two attempts, the niobium expanded so far away from the rhenium that additional beam power was required to cause generous melting of niobium, with the expectation that the liquid metal would eventually reach the rhenium and wet it. Unfortunately, in both assemblies, when the additional power was applied the rhenium melted and alloyed with the niobium. Figure 1 shows the detail of one of the resulting assemblies.

Subsequent discussions with the JPL Technical Representative led to a modification of design for this structure which amounted to a shift

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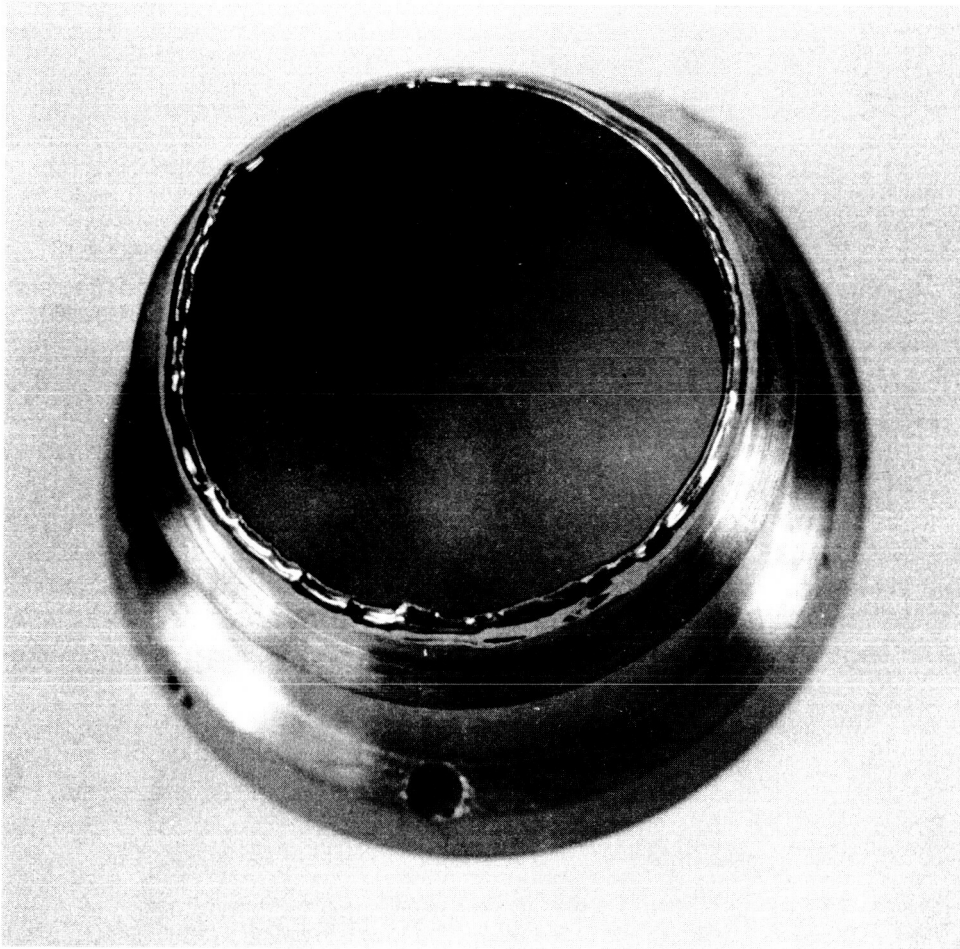


Figure 1.



from Design IV to Design III (Dwg. 555-1000, Figure 2, First Quarterly Report). As noted in the drawings describing Design III, the first weld where the niobium is melted onto the rhenium is in a region near a substantial cross section of niobium, so that radial expansion of the niobium is apt to be restrained by the cooler surrounding material. The weld attempts were successful except that the niobium lip to be melted was so short that a substantial amount of beam power impinged on the outer corner of the niobium flange and caused it to melt. This is shown in Figure 2. Since the structures were still usable, the effort proceeded with the electron-beam welding of the intermediate rhenium emitter support to the outer rhenium flange. These welds were difficult to make by electron-beam welding but they were successful. In order to eliminate the extreme care required by the end-weld of concentric thin-walled rhenium tubes by electron-beam welding, it was decided to use heliarc welding in the future, and the next weld of the inner emitter support to the intermediate emitter support, on the same assemblies, was attempted by heliarc welding. The weld failed because of misalignment of parts due to improper dimensional specification of the parts. As can be seen in Figure 3, "scalloping" occurred, because the edge of one of the rhenium tubes was located higher than that of the other, and the edge of that tube had to be completely melted away before the weld to the other tube could take place. The localized collection of beads of molten metal was so pronounced that the molten rhenium made contact at several points with the niobium of the outer seal flange, and alloyed with it. Therefore, the final assemblies were unusable.

Consequently, new parts were made with modifications to avoid the above problems, and one assembly including an electropolished rhenium

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Figure 2.

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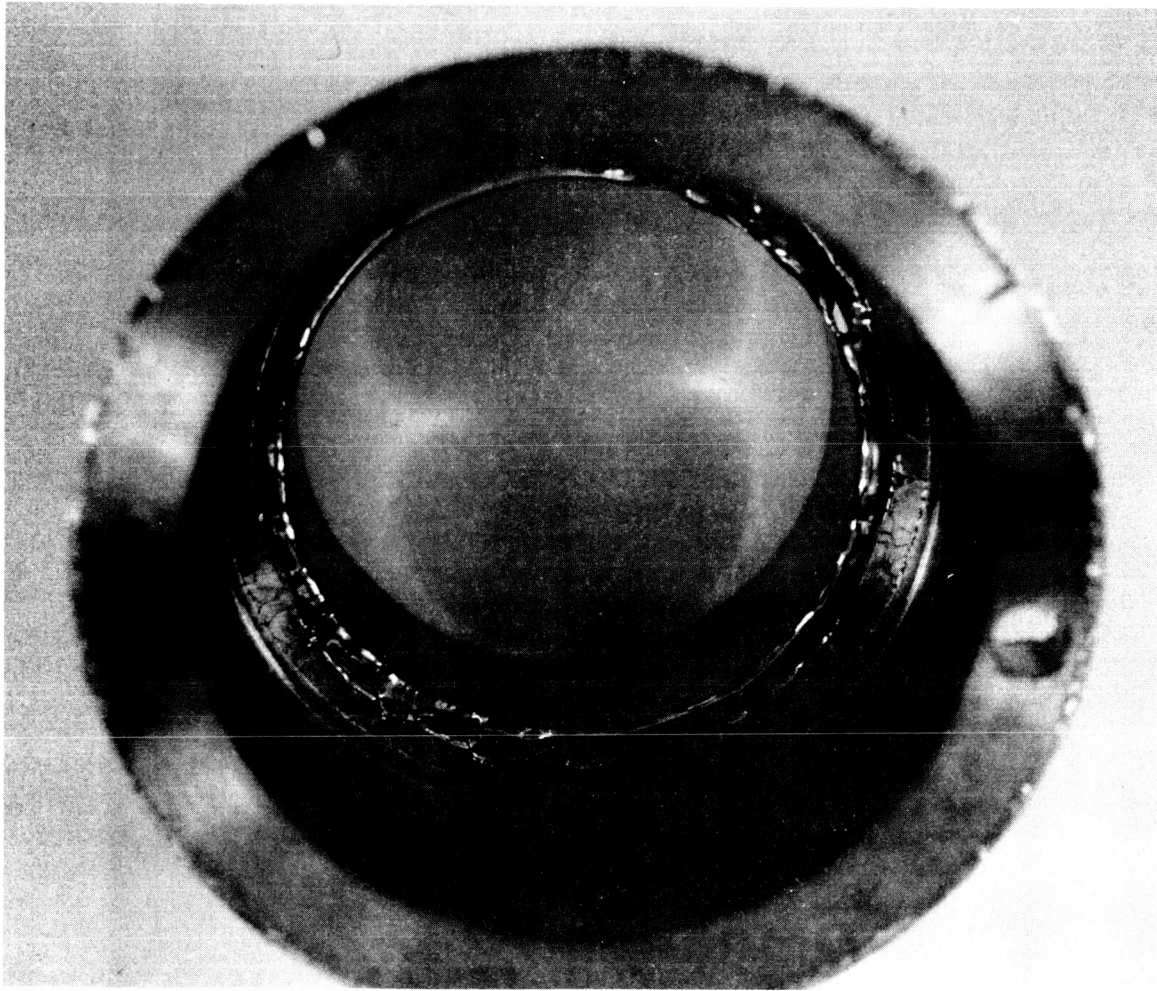


Figure 3.



emitter was successfully completed. Figures 4 and 5 show the details of the various welds. As can be noted, a slight "scalloping" is still apparent on the weld of the inner to the intermediate emitter supports, but it should disappear in subsequent assemblies as the result of further dimensional adjustment of the parts. The only defect of this assembly is a slight depression of 0.0002" in the center of the emitter caused by jig pressure used to retain this piece during electron-beam welding. The jig pressure will be reduced in the future to avoid the defect.

The completed structure shown in Figure 4 was subsequently thermally cycled by raising the hohlraum quickly ten times to 1780°C. The niobium flange temperature was monitored with a chromel-alumel thermocouple, and it varied over the range from 500°C to 900°C in each cycle. The warm-up time was 1 minute 10 seconds, and the cool-down time 3 minutes 30 seconds. After the thermal cycles were completed the structure was found to have remained leak-tight and to have maintained flatness with no visual evidence of deterioration. It was agreed with the JPL Technical Representative to use this structure for the fabrication of converter T-204.

1.3 Fabrication of Converter T-204

The design of converter T-204 included a number of modifications aimed primarily at simplifying the converter structure and its assembly procedure. The design as approved by JPL is shown in Figure 6. One of the principal changes is a reversal of the inner seal flange so that the flange reaches to the rear of the collector barrel rather than forward. This change allows a much more favorable configuration for the palladium braze of the flange to the collector. It also results in a different inter-electrode spacing which is estimated as follows:

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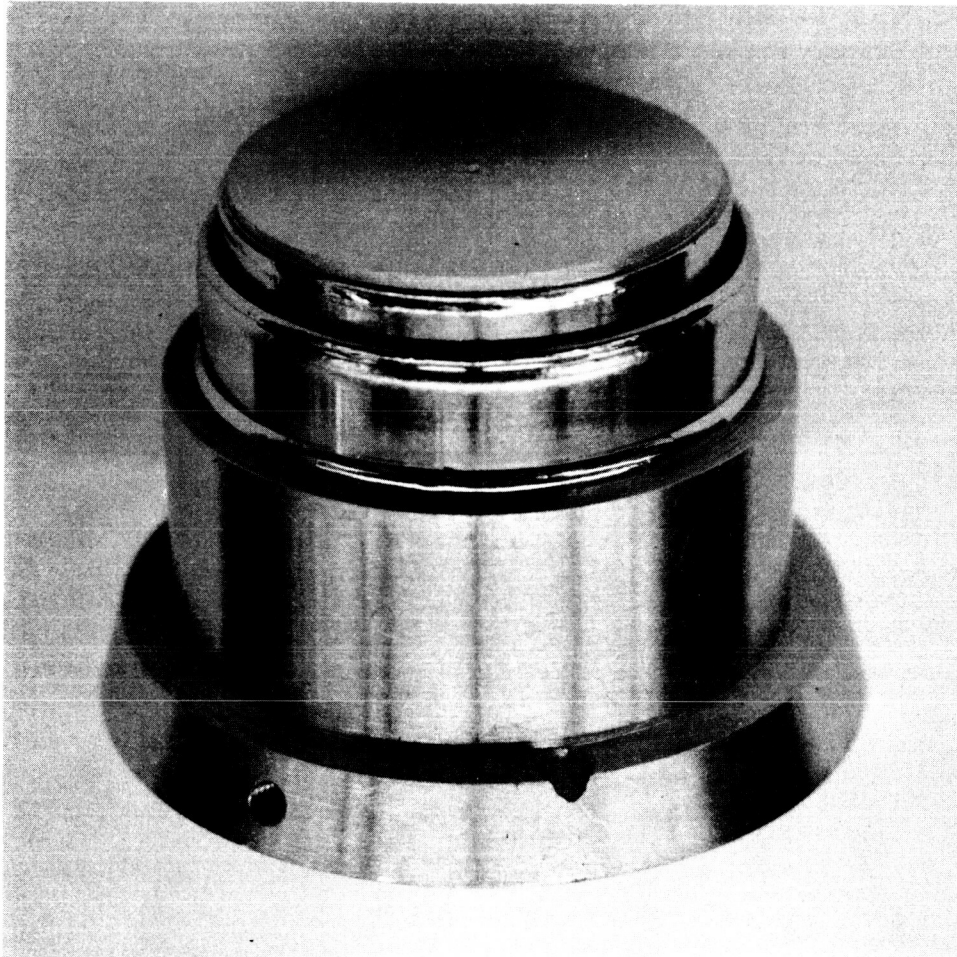


Figure 4.

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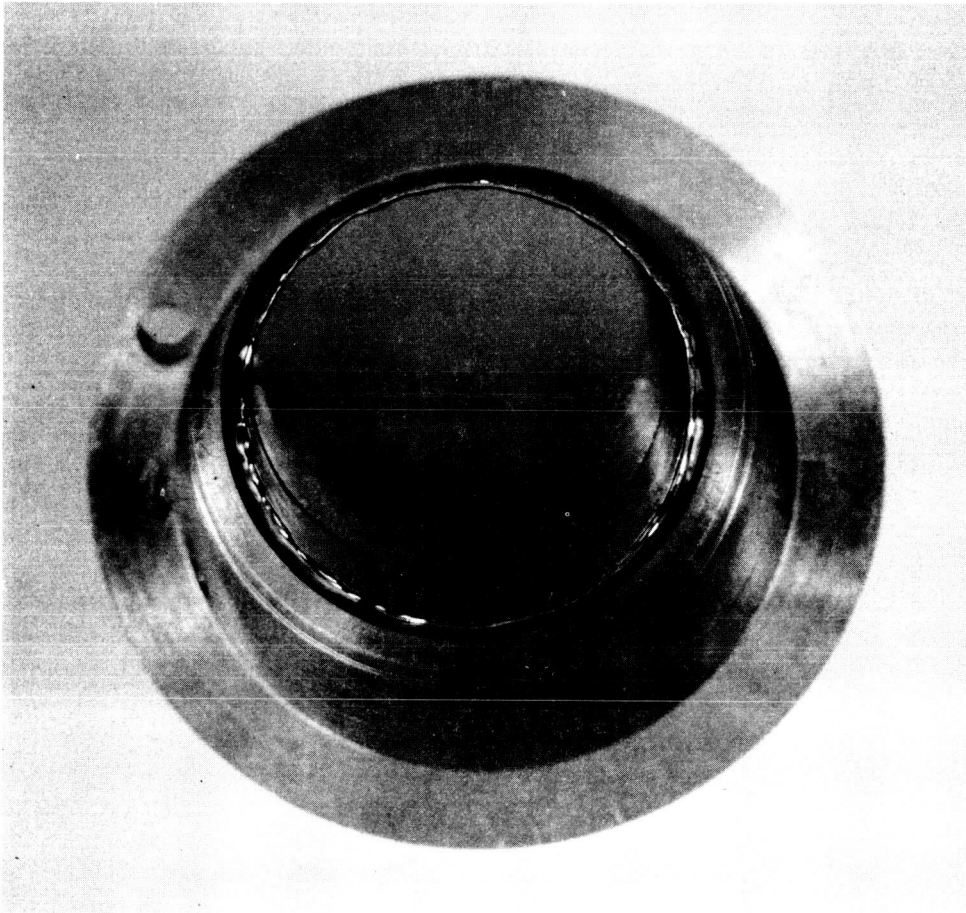
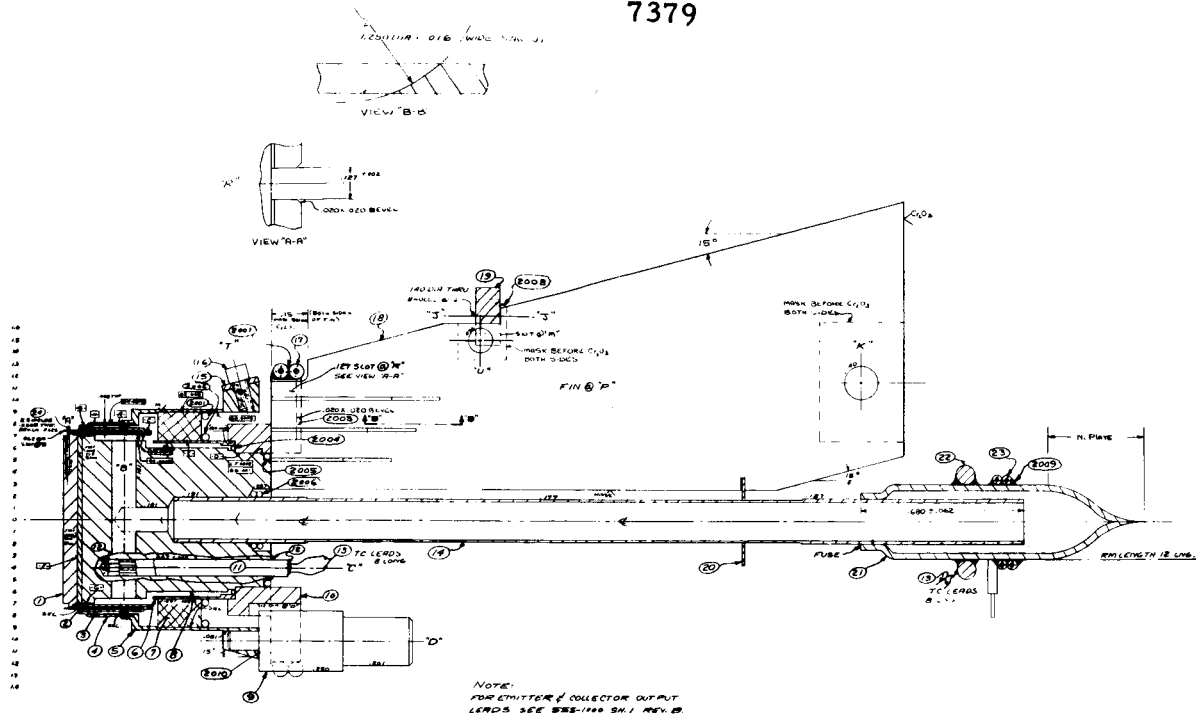


Figure 5.

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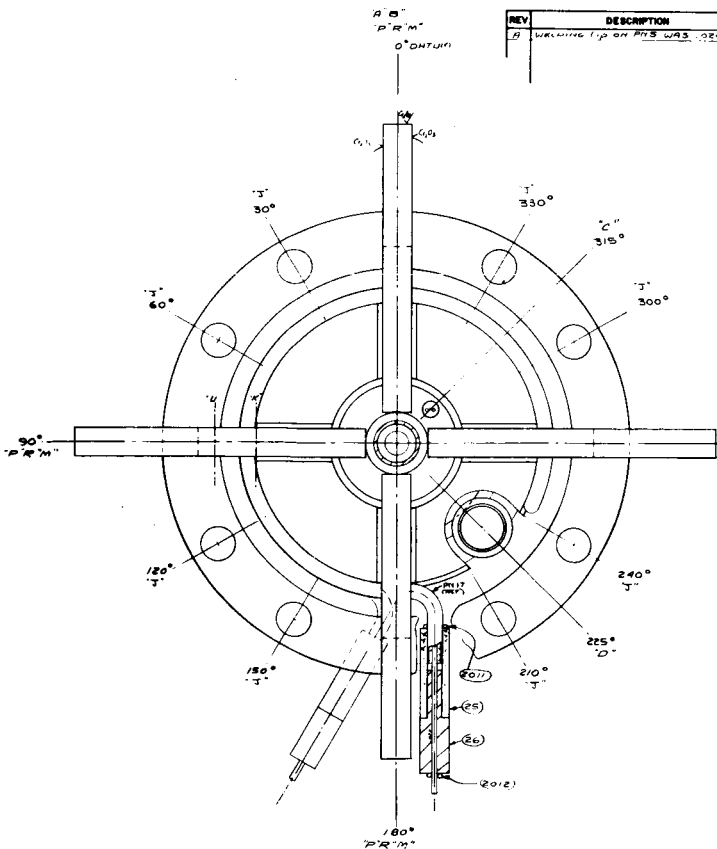


NOTE:
FOR EMITTER & COLLECTOR OUTPUT
LEADS SEE SSS-1400 SH. 1 REV. B

REV	DESCRIPTION	DATE	BY	APP
A	WELDING TYP ON PHS WAS .020 LONG	8-1-66	MM	

[illegible]

PART	SIZE	QTY	LOC	MAT'L	NOTES
BRASS					
2201	ND	1		CU .030 DIA WIRE	
2202	ND	1		CU .030 DIA WIRE	
2203	ND	1		FS30 .030 DIA WIRE	
2204	ND	1		FS .030 DIA WIRE	
2205	ND	1		CU .030 DIA WIRE	
2206	ND	2		FS30 .030 DIA WIRE	
2207	ND	1		FS30 .030 DIA WIRE	
2208	ND	1		FS30 .030 DIA WIRE	
2209	ND	1		FS30 .030 DIA WIRE	
2010	A	1		FS30 .003 THK.	
2011	ND	1		FS30 0.15 DIA	
2012	ND	2		FS30 0.15 DIA	



4 $M = \text{MET. NO. 7, } \phi \text{ IN PLATE. 0.005 IN.}$
 5 SEE FIXTURE LAYOUTS (3000, 3100 ETC.) FOR FIXTURE INFORMATION.
 6 UNK. UNKNOWN. N.D. NO DRAWING, PROCURE FROM THIS L.D.
 7 DOTTED LINES INDICATE ROUGH OR PRELIMINARY MACHINING.
 8 ALL MATING CORNERS & FILETS ARE .015 X 45° CHFR. AND COR. R.
 9 MAX. PERMISSIBLE TAP DRILL DEPTH AND MIN. PERMISSIBLE FULL
 10 THREAD DEPTHS ARE SHOWN.
 11 SECTION LOCATIONS DEFINED BY LETTER LOCATION AT END VIEW.
 12 NOTES 2 THRU 7 APPLY UNLESS OTHERWISE SPECIFIED.

[illegible]

26	A	2	S.3	WATER TERMINAL
25	A	2	AND	02.55 X 10.05 D55.4 X 3.80G
24	B	2	TA	SHIELD
23	IND	-		OUT-DIE METER WIRE
22	ND	-	M1	0.80 DIA
21	B	1	CV	EVACUATION TUBS
20	A	1	NB	CESIUM TUB SUPPORT
19	C	1	S	INSUL. SH. RING
18	D	4	CV	RADIATOR FIN
17	ND	1	-	009 DIA METER WIRE
16	ND	1	S.S	0.09 IN. DIA S.N.C.
15	C	1	CV	10.00 DIA. RINGER
14	B	1	N	CESIUM TUBS
13	ND	1	MS	TERMOCOUPLER
12	ND	1	MS	CEMENT
11	C	1	MS	INSUL. SH. RADIATOR
10	C	1	MS	RADIATOR ADAPTER
9	B	1	ND	TERMINAL STUD
8	C	1	MS	COLLECTOR BODY
7	ND	1	MS	CESIUM INSULATOR
6	C	1	NB	INNER SEAL FLANGE
5	B	1	ND	OUTER SEAL FLANGE
4	B	1	ND	OUTER EMITTER SUPPORT
3	C	1	ND	INTERMEDIATE EMITTER SH.
2	B	1	ND	INNER EMITTER SUPPORT
1	B	1	ND	EMITTER

PART	SIZE	REV	QTY	IMP L	UNITED
FOR OTHERS SPECIFICATIONS					
THERMAL ELECTRON 10000 10TH AVE. S.W. SEATTLE 1, WASH. 5 TEL. 325-0000 THERMAL ELECTRON, INC. 10000 10TH AVE. S.W. SEATTLE 1, WASH. 5 TEL. 325-0000 ALL OTHERS ARE TO BE SPECIFIED REMOVE ALL BARRIERS AND LOCKS					
SCALE: 5" = 1" (frames & 1/2 inch) 555 0000					
14 CLR-1000					

Figure 6



Take expansion of an 0.220" Re structure to an average temperature of 1200°C:	1.85 mils
Add expansion of an 0.400" Nb structure to an average temperature of 700°C:	2.20 mils
Subtract expansion of an 0.620" Mo structure to an average temperature of 640°C:	2.30 mils

Assuming that the spacing is zero at room temperature, the operating spacing calculated is 1.75 mils. Other changes were the elimination of the thermocouples at the collector base, the omission of grooves in the collector barrel to fit the radiator fins, and a simplified cesium reservoir structure.

A subassembly with the palladium niobium-to-molybdenum braze of this new configuration is shown in Figure 7. As can be seen, excellent braze flow is obtained, and three such subassemblies were made without any difficulty. The emitter of T-204 was electropolished using a 350 ml alcohol, 175 ml perchloric acid (60% concentration), 50 ml ethylene glycol monobutyl ether solution for 10 seconds at an applied potential of 23 volts and a current of 3.5 amperes. It was then thermally stabilized at 2040°C observed hohlraum temperature for 2.2 hours in a vacuum of 2×10^{-6} torr. The collector was chemically etched using the same procedure as that of T-203B. The coating used on the radiator fins was chromium carbide, and the cesium reservoir modifications of Figure 6 were not implemented. The converter was outgassed for 17 hours at an observed hohlraum temperature of 1750°C, and a collector temperature of 696°C. The final internal pressures were 1.0 and 0.6×10^{-6} torr in the hot and cold conditions.

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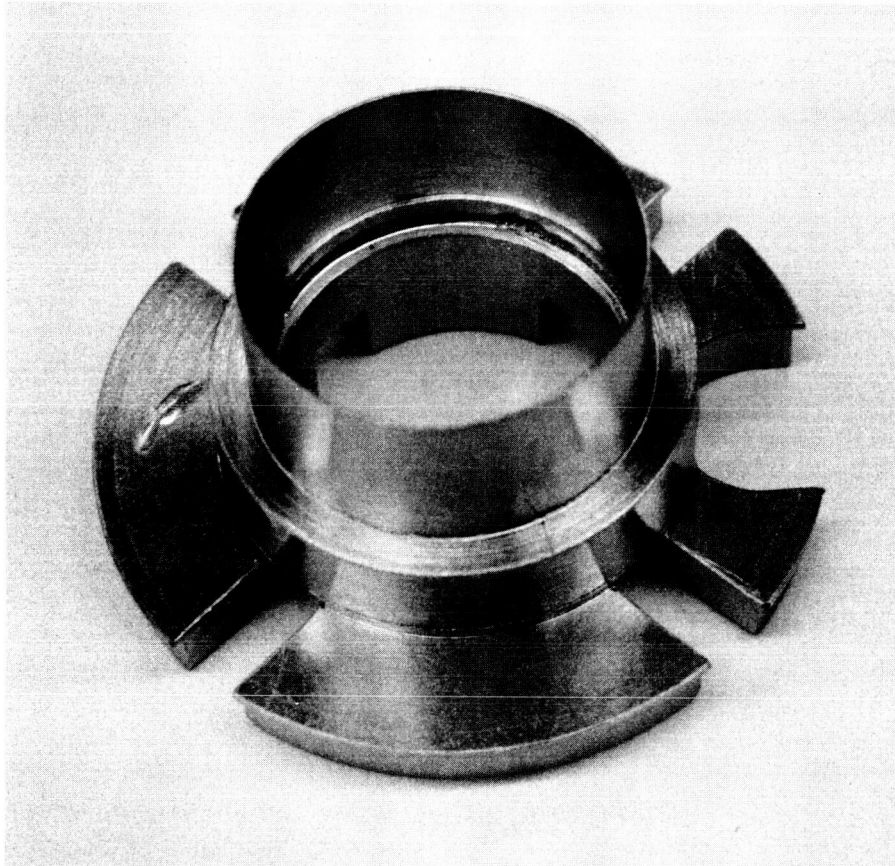


Figure 7



1.4 Emissivity Measurement of Radiator Coatings

A program was undertaken to evaluate the emissivity of various coating materials for the radiator fins. The materials tested to date are chromium carbide, zirconium carbide and chromium oxide. Two additional materials will also be tested. The tests consisted of applying a measured amount of electron-bombardment heat to wire-suspended radiator fins, and measuring their temperature when they are allowed to re-radiate in the normal vacuum-bell-jar environment. The total surface of each fin was calculated to be 34.21 cm^2 , of which 6.02 cm^2 are not coated. Assuming an emissivity of 0.2 for the uncoated areas, the heat loss of each fin should therefore be correlated by the expression:

$$q = (28.19\epsilon + 1.20) \sigma T^4$$

In order to single out the electron-bombardment filament radiation contribution to the heat input, the above expression is used to measure this contribution when the filament is operated at typical conditions without the application of an accelerating voltage. The values of ϵ that correlated the above expression are as follows:

Chromium carbide coating	$\epsilon = 0.61$ at 750°K
Zirconium carbide coating	$\epsilon = 0.61$ at 750°K
Chromium oxide coating	$\epsilon = 0.98$ at 710°K

The relatively low value for zirconium carbide may have been caused by insufficient coating thickness, since the substrate could be seen at spots through the coating. The relatively high value for chromium oxide compared with the usually reported range of 0.85 - 0.87 may have been the result of overestimating the bombardment power input. In all likelihood,



a fraction of the bombarding current bombarded targets other than the fin on test. From these results, chromium oxide coating appears to have the best thermal performance. From a practical point of view, the chromium carbide coating has been found to have superior adherence. It is felt that neither coating is the ultimate answer to the converter requirements. The zirconium carbide coating is also suspected of having poor mechanical qualities.

1.5 Performance of Converters T-203B and T-204

The data sheets and graphs at the end of the report show the performance obtained from T-203B and T-204 following the test procedures outlined in JPL Engineering Note ADEN 342-005.

The relative collector work functions are described by the output voltage at fixed operating conditions, for a selected output current. The results obtained so far in the program are as follows: For an output current of 40 amperes (16 A/cm^2), emitter temperature of 2000°K , reservoir temperature of 680°K and collector temperatures of 942 and 1042°K , the output voltages observed are:

	<u>Initial</u>		<u>Final</u>	
	$T_c = 942^\circ\text{K}$	1042°K	942°K	1042°K
T-201	0.76	0.75	0.70	0.69
T-202	0.71	0.69	0.69	0.63
T-203B	0.63	0.65	0.64	0.64

The values for T-204 were obtained at a lower emitter temperature of 1976°K and were:

T-204	—	0.71	0.62	0.66
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These values should be increased by approximately 50 millivolts in order to correct for the lower emitter temperature (the ignited branch of the optimized I-V characteristics shifts by about 200 millivolts for an emitter temperature change from 2000°K to 1900°K). So far, these relative measurements have not correlated significantly with any of the performance characteristics observed in the prototypes.

The reason for the lower emitter temperature achieved in converter T-204 is that the emitter temperature drop is larger, and in some instances the observed hohlraum temperature was set to reproduce previously obtained values. For the solid rhenium emitter, the distance from the hohlraum to the emitter face is approximately 0.045 in. or 0.114 cm. The converter heat transfer has been calculated to be approximately $(34.6 + 1.09 I)$ watts/cm² in the vicinity of 2000°K emitter temperature. Assuming the thermal conductivity of rhenium to be 0.24 watt/cm - °K at 2000°K (see p. III-44 of JPL Task IV Final Report on Contract 950671), the calculated emitter temperature drop for a solid rhenium emitter is

$$\Delta T = 20 + 0.5 I, \text{ } ^\circ\text{C}$$

where I is the output current of the converter in amperes. The above expression is just about twice the value previously observed in pressure-bonded structures of tantalum and rhenium.

In the optimized 144-hour run, the performance observed for the same four converters is as follows:



	<u>T-201</u>	<u>T-202</u>	<u>T-203B</u>	<u>T-204</u>
Emitter Temperature, °K	2000	2000	2000	1974
Output Voltage, V	0.60	0.80	0.80	0.77
Output Current, amperes	38.0	43.4	39.3	41.4
Reservoir Temperature, °K	623	621	614	618
Collector Temperature, °K	1030	1006	979	1074
Power Input, watts	302	297	299	323
Collector temperature drop, °C	223	213	177	260

As may be noted in the above table, the collector temperature of converter T-204 was considerably higher than that previously achieved, and it was, in fact, not optimum. Part of the increase in collector temperature is due to the larger amount of heat received by the converter (which could be the result of increased radiation heat transfer due to chemical etching of the collector surface), and part is due to the lack of direct heat transfer from the collector barrel to the radiator fins as a result of the design change of the collector barrel described in Section 1.3. In converter T-205 this source of collector temperature drop will be avoided. Fully optimized performance was obtained in converter T-204 by connecting a water-cooled strap to one of the radiator fins. The fully optimized I-V curves at 2000°K show the following differences in converter output current (amperes):

	<u>T-201</u>	<u>T-202</u>	<u>T-203B</u>	<u>T-204</u>
0.8 V	28.3	43.5	40.0	45.3
1.0 V	20.8	14.2*	23.2	26.0
1.2 V	14.6	10.0*	18.1	18.5

*The collector temperature of these runs was too high (1.75 times the reservoir temperature instead of 1.60).



The steady-state performance achieved with the various prototypes at an output voltage of 1 volt, with no heat applied to control collector temperature, is as follows:

Prototype:	<u>TE-103</u>	<u>T-201</u>	<u>T-202</u>	<u>T-203B</u>	<u>T-204</u>
Hohlraum Temperature, °C	1723	1700	1700	1700	1724
Output Current, amperes	32.5	14.8	12.3	17.6	29.0
Reservoir Temperature, °K	614	602	592	614	614
Collector Temperature, °K	1015	886	852	865	1002
Radiator Temperature, °K	—	737	720	739	802
Collector Temperature Drop, °C	—	149	132	126	200
Power Input, watts	282	220	202	226	292
Overall Efficiency, %	11.5	6.7	6.1	7.8	9.9

The cesium conduction heat transfer of prototypes T-203B and T-204 was measured to infer interelectrode spacing. The measurements are made at varying cesium pressures, at an emitter temperature of 2000°K and a collector temperature of 900°K. Assuming an effective area for cesium conduction 10% in excess of the 2.50 cm^2 interelectrode area, the computed variation of cesium conduction with cesium reservoir temperature is given in Figure 8 for various interelectrode spacings. The data plotted in this figure, obtained from the two converters, shows that the interelectrode spacing of converter T-203B was approximately 1.25 mils, and that of converter T-204 was 1.65 mils. This latter value agrees well with the calculated T-204 interelectrode spacing of 1.75 mils.

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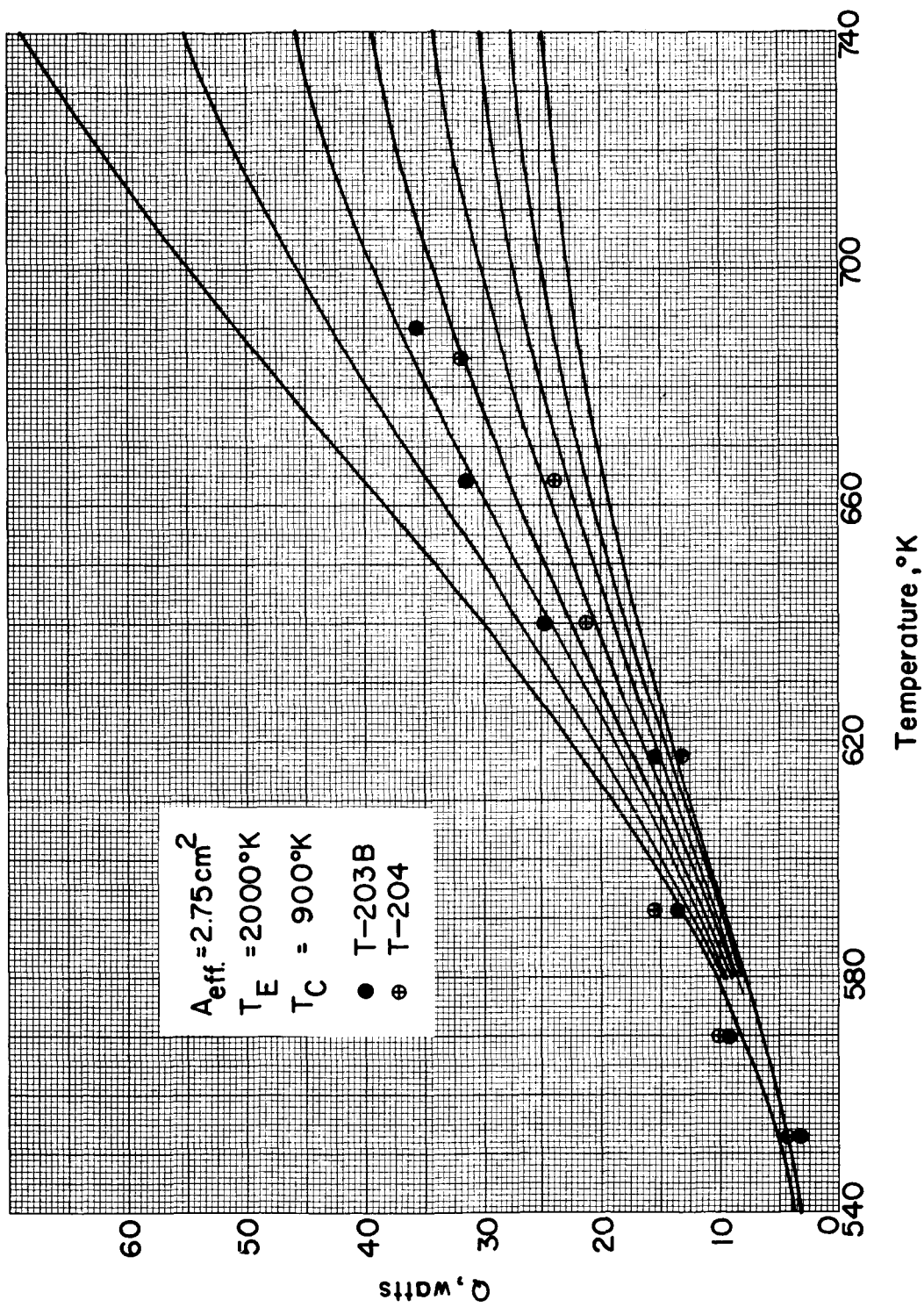
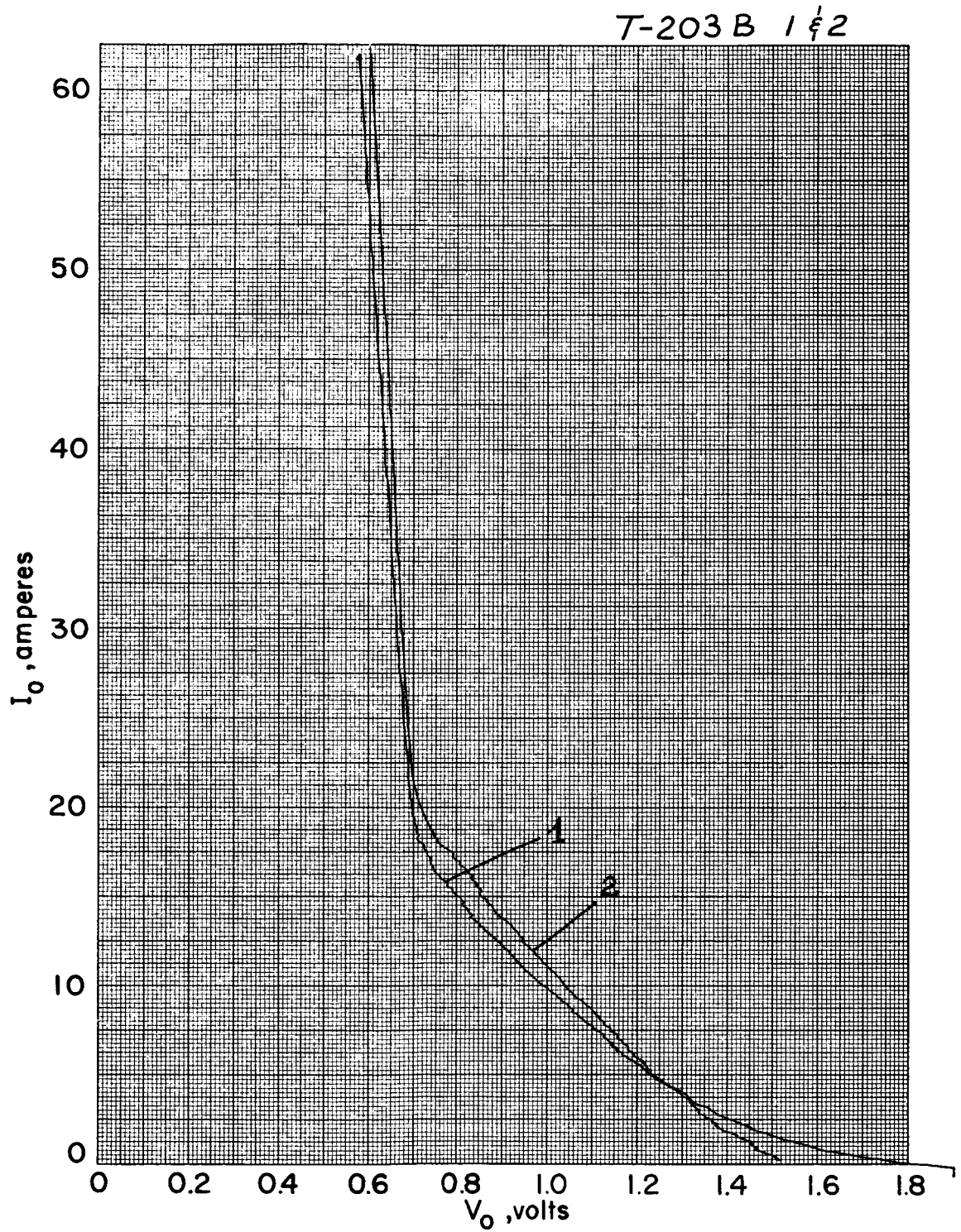


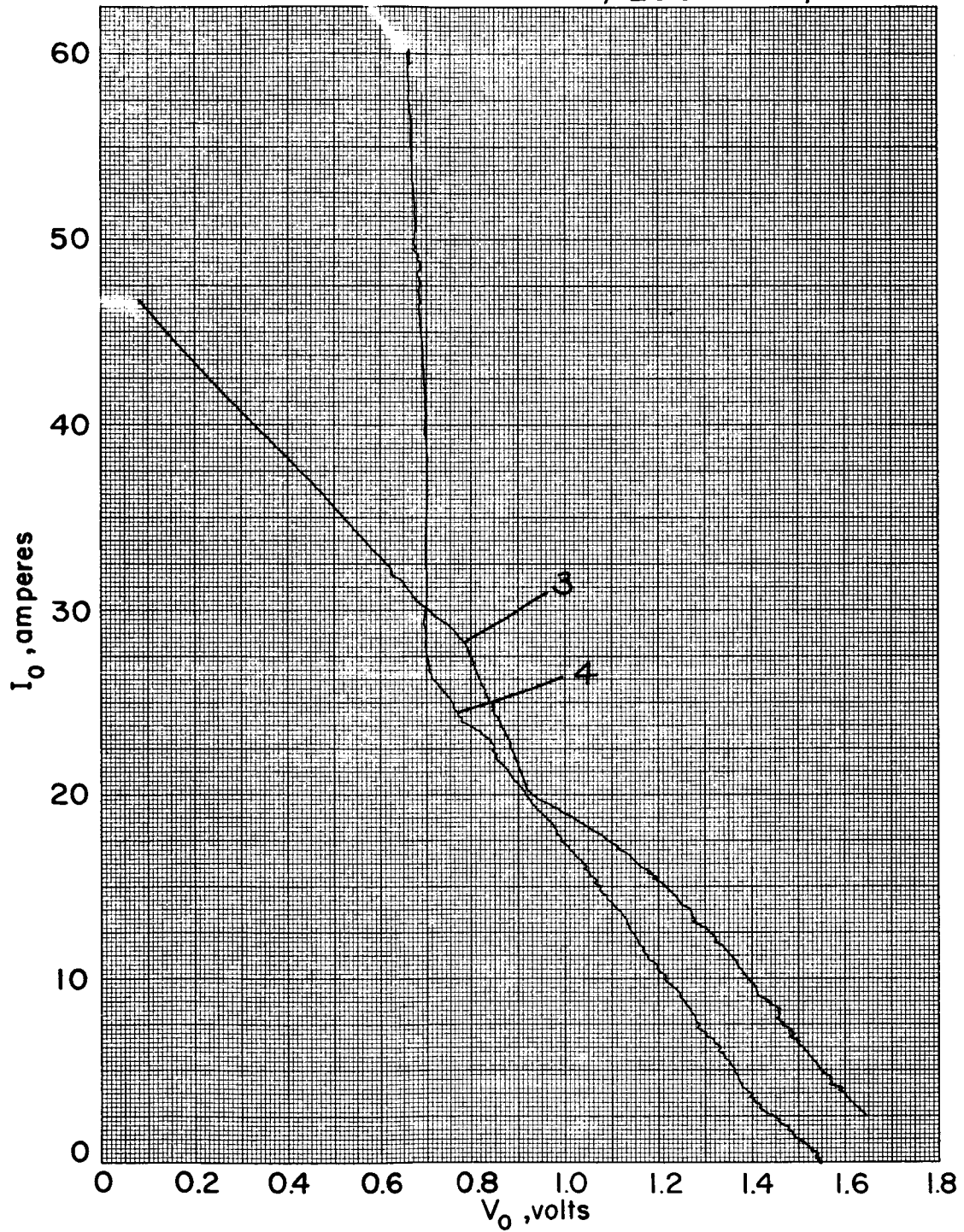
Figure 8

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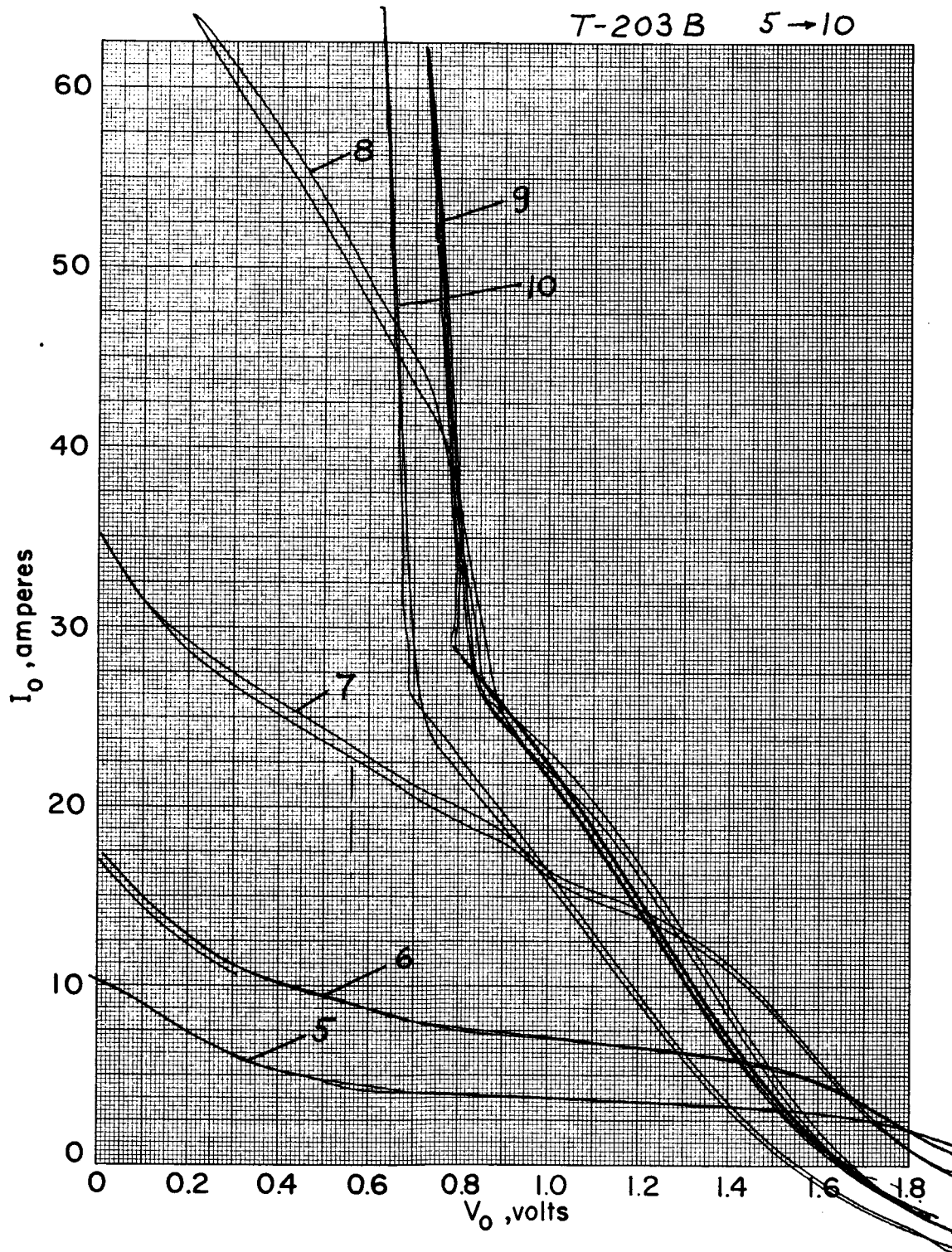


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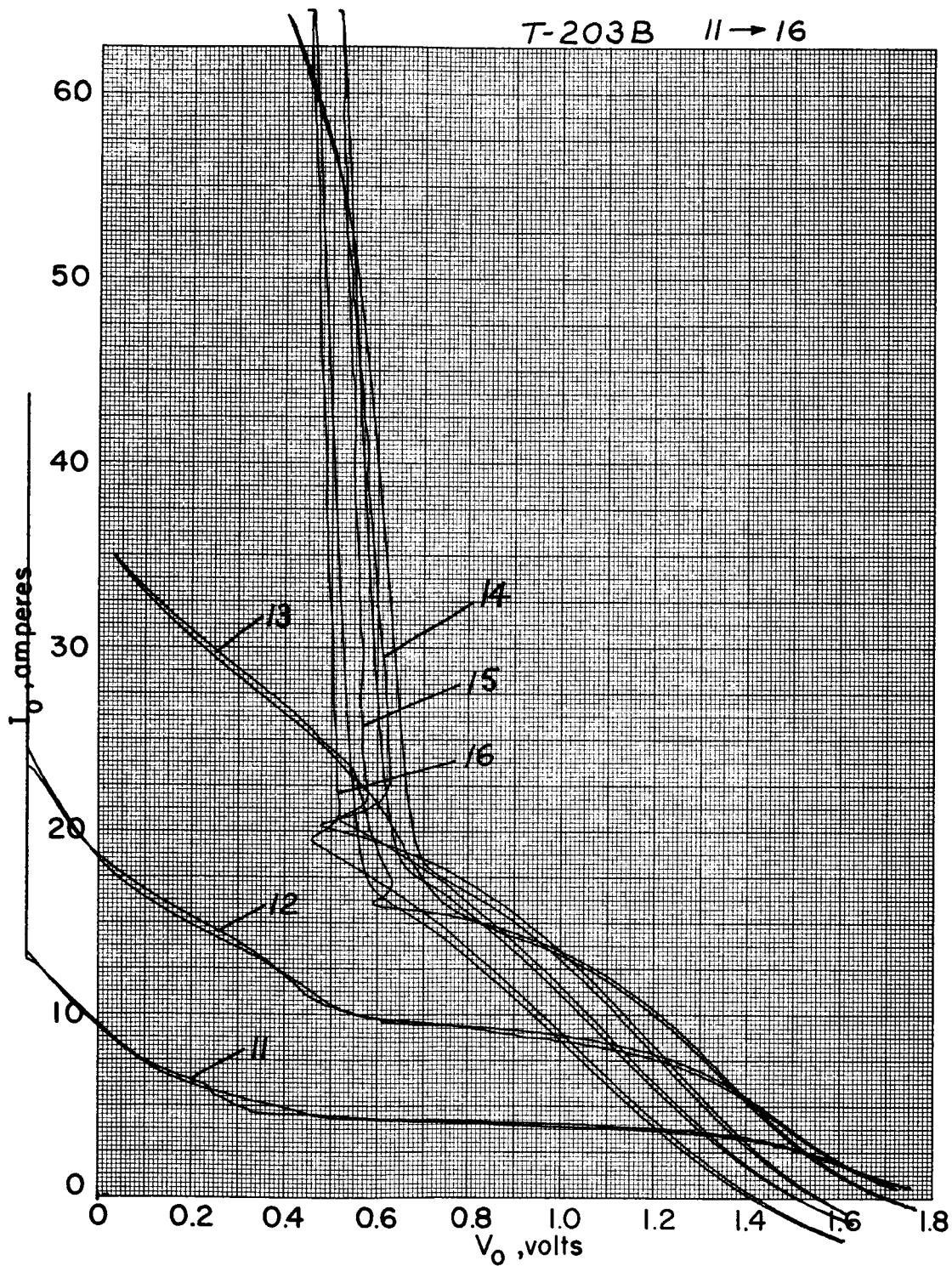
T-203B 3 & 4



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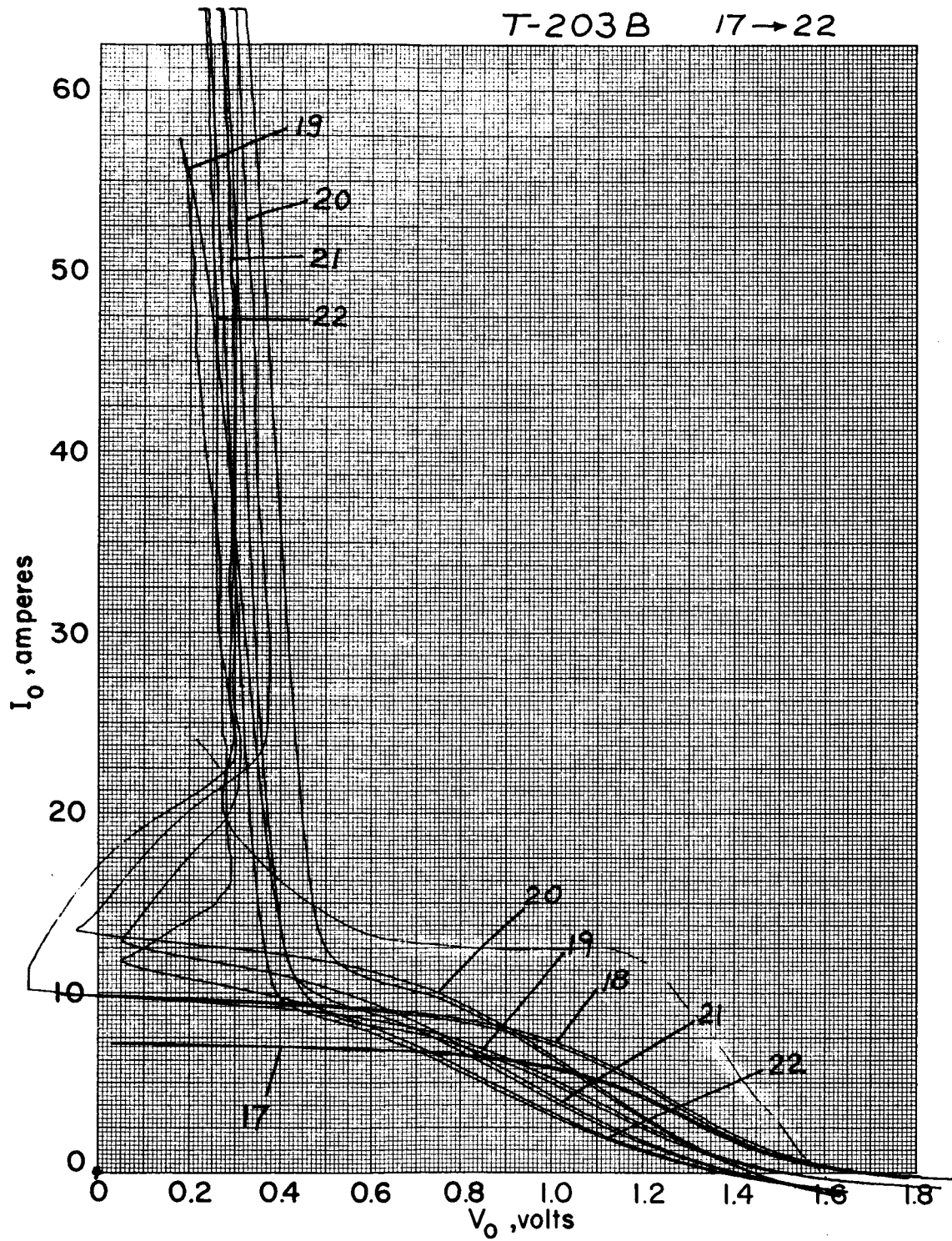


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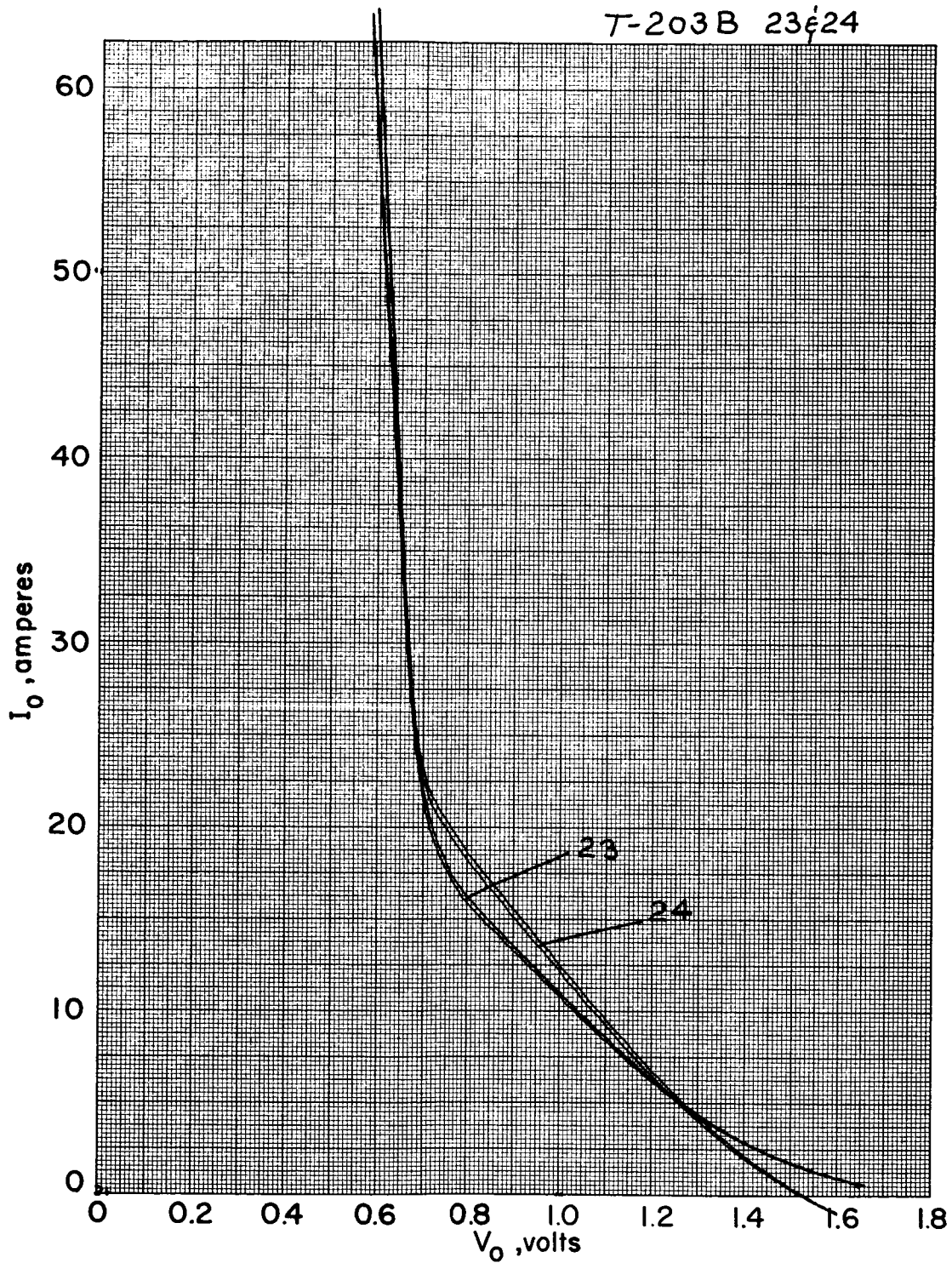


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Converter No. TE203B

Run No. _____

Observer R.B. Slosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		6/20	—	—	6/21	—	—	—	—	—	
Time		1105	1424	1700	1030	1047 ¹⁵	1142	1206	1225	1240	
Elapsed Time, Hours		—	—	—	—	—	—	—	—	—	
T ₀ , °C		1680	1680	1680	1679	1679	1680	1679	1680	1680	
T ₀ Corrected, °C		1690	1690	1690	1689	1689	1690	1689	1690	1690	
ΔT _{Bell Jar} , °C		14	14	14	14	14	14	14	14	14	
T _H , °C		1703	1703	1703	1702	1702	1703	1702	1703	1703	
ΔT _E , °C											
T _E , °K		1966	1970	1970	1970	1970	1966	1965	1966	1969	
V ₀ , volts		.8033	—	—	—	.8019	.8079	.8070	.8081	.8042	
I ₀ , amps		27.8	0	0	0	.100	31.2	30.2	30.1	10.4	
P ₀ , watts		22.3	—	—	—	.0801	25.2	24.4	24.3	8.4	
I-V Trace No.		—	—	—	—	—	—	—	—	—	
T _R	mv	13.2	5.9 ¹⁴	7.0 ¹²	7.3 ¹³	11.1	134	0-650 13.4	0-655 13.5	0-575 12.1	
	°C	324	144	172	179	273	329	329	331	297	
	°K	597	417	445	452	546	602	602	604	570	
T _C	mv	5-272	0-889	0-880	0-872	0-945	5-300	5-279	5-275	5-088	
	°C	636	430	440	436	473	650	640	647	544	
	°K	909	703	713	709	746	923	913	920	817	
T _C base inner	mv	22.9	16.7	17.1	17.0	18.1	23.6	23.1	23.3	20.4	
	°C	553	407	417	414	440	569	558	562	494	
T _C base outer	mv	22.9	16.6	17.3	17.0	19.1	23.2	23.0	23.2	20.2	
	°C	553	405	421	414	440	560	555	560	489	
T _{Radiator}	mv	20.4	15.3	15.9	15.9	16.6	20.5	20.4	20.6	18.4	
	°C	494	374	388	388	405	497	494	499	447	
V _{eb} , volts		978	996	995	995	991	977	978	978	985	
I _{eb} , mA		248	149	150	151.6	169.1	268	259	257	190.1	
E _{Filament} , volts		4.8	4.9	4.8	4.7	4.7	5.0	4.9	4.8	4.6	
I _{Filament} , amps		19	19	18.5	18.5	19.5	19	19	19	18.2	
I _{Coll. Heater} , amps		0	0	0	0	0	0	0	0	0	
I _{Res. Heater} , amps		0	0	0	0	3	3.5	3.5	3.5 ¹⁵	3.0 ¹⁶	
Vacuum, 10 ⁻⁶ mm Hg		.74	68.	3.8	3.0	3.2	4.8	2.4	1.8	0.86	
Measured Efficiency, %											

NOTES: 1. Res. has a cooling Fin. ≈ 2.5 sq. in. of radiating area.
 2. " " " " ≈ 1.25 sq. in. " " "
 3. " " " " ≈ 0.625 sq. in. " " "
 4. I₀ first observed under these conditions.
 5. I_R decreased to 3A after readings where taken I₀ began to decrease.
 6. I_R decreased to 0 after readings where taken I₀ began to decrease



Converter No. TE 203 B Run No. _____ Observer R.B. Slosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		6/21 ¹	6/22 ¹²	—	— ¹⁴	—	—	—	6/23	—	
Time		1620	1150	1116	1439	1522	1622	1700	1042	1255	
Elapsed Time, Hours		—	—	—	—	—	—	—	—	—	
T ₀ , °C		1690	1680	1680	1682	1690	1690	1690	1690	1690	
T ₀ Corrected, °C		1700	1690	1690	1692	1700	1700	1700	1700	1700	
ΔT _{Bell Jar} , °C		14	14	14	14	14	14	14	14	14	
T _H , °C		1714	1703	1703	1706	1714	1714	1714	1714	1714	
ΔT _E , °C											
T _E , °K		2002	1970	1966	1974	2002	2002	1976	1976	2002	
V ₀ , volts		.7440	.7523	.8024	.7598	.7909	.7946	.8087	.8089	.7940	
I ₀ , amps		0	.1	30.2	.2	1.2	1.6 ¹⁶	31.7	31.5	1.7	
P ₀ , watts		0	.0752	24.23	.152	.949	.4767	25.64	25.58	1.355	
I-V Trace No.		—	—	—	—	—	—	—	—	—	
T _R	mv	0-402 ¹ 8.3	0-420 ¹² 8.9	0-654 13.9	0-420 9.0	0-495 10.4	0-506 10.6	0-654 13.6	0-662 13.9	0-511 10.6	
	°C	204	219	341	222	256	261	333	341	261	
	°K	477	492	614	495	529	534	606	614	534	
T _C	mv	0-900	0-884	5-280	0-870	0-934	0-944	5-314	5-299	0-961	
	°C	450	442	640	435	467	472	657	649	480	
	°K	723	715	913	708	740	745	930	922	753	
T _C base inner	mv	17.2	17.3	23.4	17.0	18.0	18.1	23.3	23.6	18.2	
	°C	419	421	564	414	438	440	562	569	443	
T _C base outer	mv	17.2	17.2	23.2	17.0	17.9	18.1	23.3	23.5	18.2	
	°C	419	417	560	414	436	440	562	567	443	
T _{Radiator}	mv	15.9	15.9	20.5	15.9	16.5	16.7	20.5	20.9	16.7	
	°C	388	388	497	388	402	407	497	506	407	
V _{eb} , volts		994	995	978	994	991	990	975	978	989	
I _{eb} , mA		156	152	261	154	163	164	274	269	164	
E _{Filament} , volts		4.6	4.6	5.0	4.7	4.6	4.6	4.9	4.8	4.5	
I _{Filament} , amps		18.4	18.3	19.0	18.5	18.1	18	19	19	18	
I _{Coll. Heater} , amps		0	0	0	0	0	0	0	0	0	
I _{Res. Heater} , amps		0	0	2 ¹³	0	0	0 ¹⁵	1.2 ¹²	1.3 ¹²	0	
Vacuum, 10 ⁻⁶ mm Hg		3.2	5.0	3.8	8.0	2.0	0.98	1.4	0.46	.24	
Measured Efficiency, %											

NOTES: 1. Painted Res.
2. $\approx 1/3$ of Res. Painted
3. I_R decreased to 0 after readings where taken. I₀ began to dec.
4. No Paint on Res.
5. I_R applied after readings where taken.
6. Equilibrium
7. I_R decreased to 0 after readings taken.

Converter No. TE-203B Run No. 1,243 Observer RBS/sek

VARIABLE	1	2	3	4	5	6	7	8	9	10
Date	6/23	6/23	6/24	—	—	—	—	6/27	6/27	6/28
Time	1612	1626	0942	1003	1051	1156	1755	0850	1642	0848
Elapsed Time, Hours	—	—	—	—	0 ¹²	1.1	6.0	69.9	77.8	93.8
T ₀ , °C	1710	1710	1710	1710	1720	1715	1721	1720	1720	1722
T ₀ Corrected, °C	1720	1720	1720	1720	1730	1725	1731	1730	1730	1732
ΔT _{Bell Jar} , °C	14	14	14	14	14	14	14	14	14	14
T _H , °C	1734	1734	1734	1734	1744	1739	1745	1744	1744	1746
ΔT _E , °C										
T _E , °K	1998	1998	1998	1998	1998	2008	2005	2004	2004	2006
V ₀ , volts	1.34	1.344	1.341	1.342	.8019	.8009	.7999	.7990	.8059	.8069
I ₀ , amps	21.4 _{av}	26.5 _{av}	24.1 _{av}	26.1 _{av}	38.8	39.1	40.2	37.9	38.3	38.6
P ₀ , watts	28.68	35.62	32.99	35.3	31.1	31.32	32.2	30.3	30.9	31.2
I-V Trace No.	1	2	3	4	—	—	—	—	—	—
T _R	mv	0-814 16.9	0-814 16.9	0-642 11.9	0-722 13.3	0-668 13.9	0-666 13.9	0-674 13.9	0-666 13.9	0-669 13.9
	°C	412	412	292	326	341	341	341	341	341
	°K	685	685	565	599	614	614	614	614	614
T _C	mv	5-338	5-538	5-350	5-518	5-380	5-396	5-416	5-396	5-408
	°C	669	769	675	759	690	698	708	698	702
	°K	942	1042	948	1032	963	971	981	981	973.5
T _C base inner	mv	24.4	27.3	22.9	26.3	24.9	24.9	24.6	24.4	24.9
	°C	588	656	553	633	600	600	592	588	600
T _C base outer	mv	24.3	27.9	22.9	26.3	24.9	24.9	24.9	24.2	24.9
	°C	586	671	553	633	600	600	600	583	600
T _{Radiator}	mv	21.4	23.9	19.9	22.2	21.9	21.9	21.9	21.9	21.9
	°C	518	576	483	537	529	529	529	529	529
V _{eb} , volts		979	977	984	982	976	975	974	974	975
I _{eb} , mA		256.5	269	249.2	259	299	300	305	298.3	301.6
E _{Filament} , volts		4.8	4.8	4.8	4.8	5.0	5.0	5.0	4.9	5.0
I _{Filament} , amps		19	19	18.8	18.9	19.1	19.1	19.4	19	19.1
I _{Coll. Heater} , amps		3	9.5	7	10	0	0	0	0	0
I _{Res. Heater} , amps		2	1.0	0	0	0	0	0	0	0
Vacuum, 10 ⁻⁶ mm Hg		0.48	0.8	0.54	0.54	0.36	0.34	0.25	0.32	0.11
Measured Efficiency, %										

NOTES: 1. this is the lowest Cs. temp. that could be reached
2. Timer set.



Converter No. TE203B Run No. 344 Observer R.B. Slosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		6/28	6/28	6/29	7/1	—	—	—	—	—	—
Time		1405	1540	0935	0850	1645	1654	1700	1712	1724	1735
Elapsed Time, Hours		99.2	100.7	118.6	165.9	—	—	—	—	—	—
$T_0, ^\circ\text{C}$		1728	1721	1725	1720	1720	1730	1730	1720	1730	1710
T_0 Corrected, $^\circ\text{C}$		1738	1731	1735	1730	1730	1740	1740	1730	1740	1720
$\Delta T_{\text{Bell Jar}}, ^\circ\text{C}$		14°	14	14	14	14	14	14	14	14	14
$T_H, ^\circ\text{C}$		1762	1745	1750	1744	1744	1754	1754	1744	1754	1734
$\Delta T_E, ^\circ\text{C}$											
$T_E, ^\circ\text{K}$		2015	2005	2009	1998	1998	2022	2020	1998	2019	1999
V_0 , volts		8042	8059	8070	8069	—	—	—	—	—	—
I_0 , amps		35.2	39.3	39.5	36.9	4.9ar	7.9ar	14.9ar	22.9ar	22.0ar	24.9ar
P_0 , watts		26.7	31.7	31.9	29.8	—	—	—	—	—	—
I-V Trace No.		—	—	—	—	5	6	7	8	9	10
T_R	mv	0-649 13.1	0-674 13.9	0-674 13.9	0-659 13.9	0-542 11.9	0-580 11.9	0-618 12.9	0-700 13.4	0-744 14	0-744 15.2
	$^\circ\text{C}$	321	341	341	341	292	292	317	329	343	372
	$^\circ\text{K}$	594	614	614	614	565	565	590	602	616	645
T_C	mv	5-356	5-413	5-419	5-382	5-154	5-254	5-320	5-400	5-448	5-518
	$^\circ\text{C}$	678	706	709	691	597	627	660	700	724	759
	$^\circ\text{K}$	951	979	982	964	870	900	933	973	997	1032
T_C base inner	mv	23.9	24.7	24.9	24.9	22.9	23.9	24.9	25.9	26.1	27.9
	$^\circ\text{C}$	576	595	600	600	553	576	600	623	628	671
T_C base outer	mv	23.9	24.7	24.9	24.9	22.9	23.9	24.9	25.9	26.0	27.9
	$^\circ\text{C}$	576	595	600	600	553	576	600	623	626	671
T_{Radiator}	mv	20.9	21.9	21.9	21.9	20.0	20.9	21.9	22.0	22.9	23.9
	$^\circ\text{C}$	506	529	529	529	485	506	529	532	553	576
V_{eb} , volts		975	975	973	972	994	991	986	982	982	982
I_{eb} , mA		288.9	307.5	309.9	300	1739	200.9	230	259	259	260
E_{Filament} , volts		4.9	5.0	5.0	5.0	4.8	4.8	4.8	4.9	4.8	4.8
I_{Filament} , amps		19	19	19.1	19.1	18.5	18.8	18.9	19	19	19
$I_{\text{Coll. Heater}}$, amps		0	0	0	0	9	9	9.5	9.5	9.5	10.0
$I_{\text{Res. Heater}}$, amps		0	0	0	0	2	2	2	2.5	3.0	3.0
Vacuum, 10^{-6} mm Hg		0.089	0.1	0.14	0.62	1.0	6.2	4.4	4.2	3.4	4.2
Measured Efficiency, %											

NOTES:



Converter No. TF 203 B Run No. 4 Observer R B S / o s e k

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		7/5	-	-	-	-	-	-	-	-	-
Time		1038	1050	1125	1138	1150	1204	1322	1350		1442
Elapsed Time, Hours		-	-	-	-	-	-	-	-	-	-
$T_0, ^\circ\text{C}$		1610	1620	1630	1618	1630	1621	1500	1520	1500	1510
T_0 Corrected, $^\circ\text{C}$		1619	1629	1639	1627	1639	1630	1509	1529	1509	1519
$\Delta T_{\text{Bell Jar}}, ^\circ\text{C}$		12	12	12	12	12	12	12	12	12	12
$T_H, ^\circ\text{C}$		1632	1642	1652	1640	1652	1641	1518	1539	1518	1529
$\Delta T_E, ^\circ\text{C}$											
$T_E, ^\circ\text{K}$		1898	1908	1918	1902	1918	1905	1786	1806	1786	1792
V_0 , volts		-	-	-	-	-	-	-	-	-	-
I_0 , amps		12 am	18.4 am	15.3 am	27.9 am	28 am	24 am	3.4 am	4.9 am	20 am	27.9 am
P_0 , watts		-	-	-	-	-	-	-	-	-	-
I-V Trace No.		11	12	13	14	15	16	17	18	19	20
T_R	mv	0-544 11.2	0-570 12	0-620 12.9	0-658 13.7	0-700 14.0	0-744 15.4	0-542 11.4	570 11.9	0-620 12.9	0-658 13.5
	$^\circ\text{C}$	276	295	317	336	343	376	280	292	317	331
	$^\circ\text{K}$	549	568	590	609	616	649	553	565	590	604
T_C	mv	5-194	5-254	5-320	5-400	5-448	5-518	5-194	5-254	5-320	5-400
	$^\circ\text{C}$	597	627	660	700	724	759	597	627	660	700
	$^\circ\text{K}$	870	900	933	973	997	1032	870	900	933	973
T_C base inner	mv	23.0	23.8	24.9	25.9	26.0	27.9	23.1	24.0	24.9	26.0
	$^\circ\text{C}$	555	574	600	623	626	671	558	579	600	626
T_C base outer	mv	22.9	23.8	24.9	25.9	26.0	27.9	23.1	24.2	24.9	26.0
	$^\circ\text{C}$	553	574	600	623	626	671	558	583	600	626
T_{Radiator}	mv	20.2	20.9	21.6	22.5	23.0	23.9	20.4	21.2	21.8	22.5
	$^\circ\text{C}$	489	506	522	543	555	576	494	513	527	543
V_{eb} , volts		990	986	986	980	979	980	999	995	988	982
I_{eb} , mA		153	180	193	230	238	232.9	121.9	136.4	162.9	200
E_{Filament} , volts		4.5	4.6	4.6	4.7	4.8	4.8	4.4	4.4	4.6	4.6
I_{Filament} , amps		12.5	18.0	18	18.2	18.5	18.6	17.2	17.5	18.0	18.0
$I_{\text{Coll. Heater}}$, amps		8.5	8.5	9	9.5	9.6	10.5	10	10.5	10.5	10.5
$I_{\text{Res. Heater}}$, amps		1	1	1	1	1	2	1	2	2	2
Vacuum, 10^{-6} mm Hg		.32	.32	.32	.44	.72	1.0	1.0	.40	.24	.30
Measured Efficiency, %											

NOTES:

Converter No. TF-203B Run No. 4546 Observer RB S/sek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		7/5	-	7/6	-	-	-	-	-	-	-
Time		1532	1555	1635	1110	1145	1200	1215	1255	1307	1420
Elapsed Time, Hours		-	-	-	-	-	-	-	-	-	-
T_0 , °C		1520	1570	1715	1718	1710	1710	1712	1718	1710	1705
T_0 Corrected, °C		1529	1519	1725	1728	1720	1720	1722	1728	1720	1715
$\Delta T_{\text{Bell Jar}}$, °C		12	12	14	14	14	14	14	14	14	14
T_H , °C		1539	1529	1740	1742	1734	1734	1736	1742	1734	1729
ΔT_E , °C											
T_E , °K		1802	1792	2000	2004	2002	2002	2004	2010	2002	1997
V_0 , volts		-	-	-	-	0	0	0	0	0	0
I_0 , amps		26.22	27.22	27.14	27.22	0	0	0	0	0	0
P_0 , watts		-	-	-	-	-	-	-	-	-	-
I-V Trace No.		21	22	23	24	-	-	-	-	-	-
T_R	mv	0-700 14.9	0-744 15.2	0-814 16.9	0-814 16.9	10.3	11.4	12.1	13.0	14.1	15
	°C	364	372	412	412	253	280	297	319	345	367
	°K	637	645	685	685	526	553	570	592	618	640
T_C	mv	5-448	5-518	5-338	5-538	5-254	5-254	5-254	5-254	5-254	5-254
	°C	724	759	669	769	627	627	627	627	627	627
	°K	997	1032	942	1042	900	900	900	900	900	900
T_C base inner	mv	26.5	26.9	23.9	27.9	24.3	24.1	24.0	24.4	24.0	23.6
	°C	637	647	576	671	586	581	579	584	579	569
T_C base outer	mv	26.9	27.0	23.9	27.9	24.3	24.2	24.2	24.4	24.2	23.6
	°C	647	649	576	671	586	581	581	588	583	569
T_{Radiator}	mv	23.0	23.2	20.9	23.9	21.2	21.3	21.3	21.2	21.2	20.9
	°C	555	560	506	576	513	516	516	513	513	506
V_{eb} , volts		984	984	979	978	995	995.1	992.9	992	991.9	990
I_{eb} , mA		193	191.7	279	276.9	165	168.9	175.4	180.0	181.9	191
E_{Filament} , volts		4.6	4.6	4.8	4.8	4.5	4.5	4.5	4.55	4.55	4.6
I_{Filament} , amps		18	18	18.8	18.8	12.6	12.6	12.8	12.9	12.9	18
$I_{\text{Coll. Heater}}$, amps		10.5	10.5	0	9	11	11	11	11	11	8.5
$I_{\text{Res. Heater}}$, amps		2	2	5	4	0	1	1	1	2.5	3
Vacuum, 10^{-6} mm Hg		.48	.48			.20	.68	.68	.68	.20	.20
Measured Efficiency, %											

NOTES:

166.16 168.07 174.15 178.56 180.42 189.09



Converter No. TE-203B Run No. 6+7 Observer R.B. Josek

VARIABLE	1	2	3	4	5	6	7	8	9	10
Date	7/6	-	7/7	-	-	-	-	-	-	-
Time	1430	1445	1315	1328	1340	1355	1410	1425	1440	1500
Elapsed Time, Hours	-	-	-	-	-	-	-	-	-	-
T_0 , °C	1710	1710	1580	1580	1580	1585	1580	1675	1680	1675
T_0 Corrected, °C	1720	1720	1589	1589	1589	1594	1589	1684	1689	1684
$\Delta T_{\text{Bell Jar}}$, °C	14	14	12	12	12	12	12	14	14	14
T_H , °C	1734	1734	1600	1600	1600	1606	1600	1698	1704	1698
ΔT_E , °C										
T_E , °K	2002	2002	1866	1866	1866	1872	1869	1960	1966	1963
V_0 , volts	0	0	6.009	8.073	1.0	1.204	1.347	6.135	9.022	1.00
I_0 , amps	0	0	16.0	11.3	8.4	4.5	2.0	49.8	25	17.6
P_0 , watts	0	0	9.6	9.1	8.4	5.4	2.7	30.6	20.1	17.6
I-V Trace No.	-	-	-	-	-	-	-	-	-	-
T_R	mv	16	17.1	13.9	13.9	13.9	13.9	13.9	13.9	13.9
	°C	391	417	341	341	341	341	341	341	341
	°K	664	690	614	614	614	614	614	614	614
T_C	mv	5-254	5-254	5-108	5-070	5-023	5-000	5-00	5-423	5-254
	°C	627	627	554	535	511.5	500	500	736	627
	°K	900	900	827	808	784.5	773	773	1009	900
T_C base inner	mv	23.5	23.9	20.5	20.0	19.3	18.7	18.4	25.5	22.6
	°C	576	576	497	485	468	454	447	614	546
T_C base outer	mv	23.9	23.9	20.3	19.7	19.2	18.9	18.3	25.4	22.6
	°C	576	576	492	478	466	459	445	612	546
T_{Radiator}	mv	20.9	20.9	18.4	17.9	17.9	17.1	16.9	22.1	20.1
	°C	506	506	447	436	436	417	412	534	487
V_{eb} , volts		989.5	988.9	985	988	990	992	994	971	979.5
I_{eb} , mA		197.9	202.4	191.5	181	173.2	162.7	155.1	315.5	249.0
E_{Filament} , volts		4.6	4.6	4.6	4.6	4.6	4.6	4.45	5.0	4.8
I_{Filament} , amps		18	18	18	18	18	18	17.8	19	18.5
$I_{\text{Coll. Heater}}$, amps		8.5	8.5	0	0	0	0	0	0	0
$I_{\text{Res. Heater}}$, amps		4.5	4.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Vacuum, 10^{-6} mm Hg		.20	.20	.10	.10	.10	.10	.10	.12	.10
Measured Efficiency, %										

NOTES: 1. Highest V_0 possible.
2. Lowest V_0 " 19582 20015

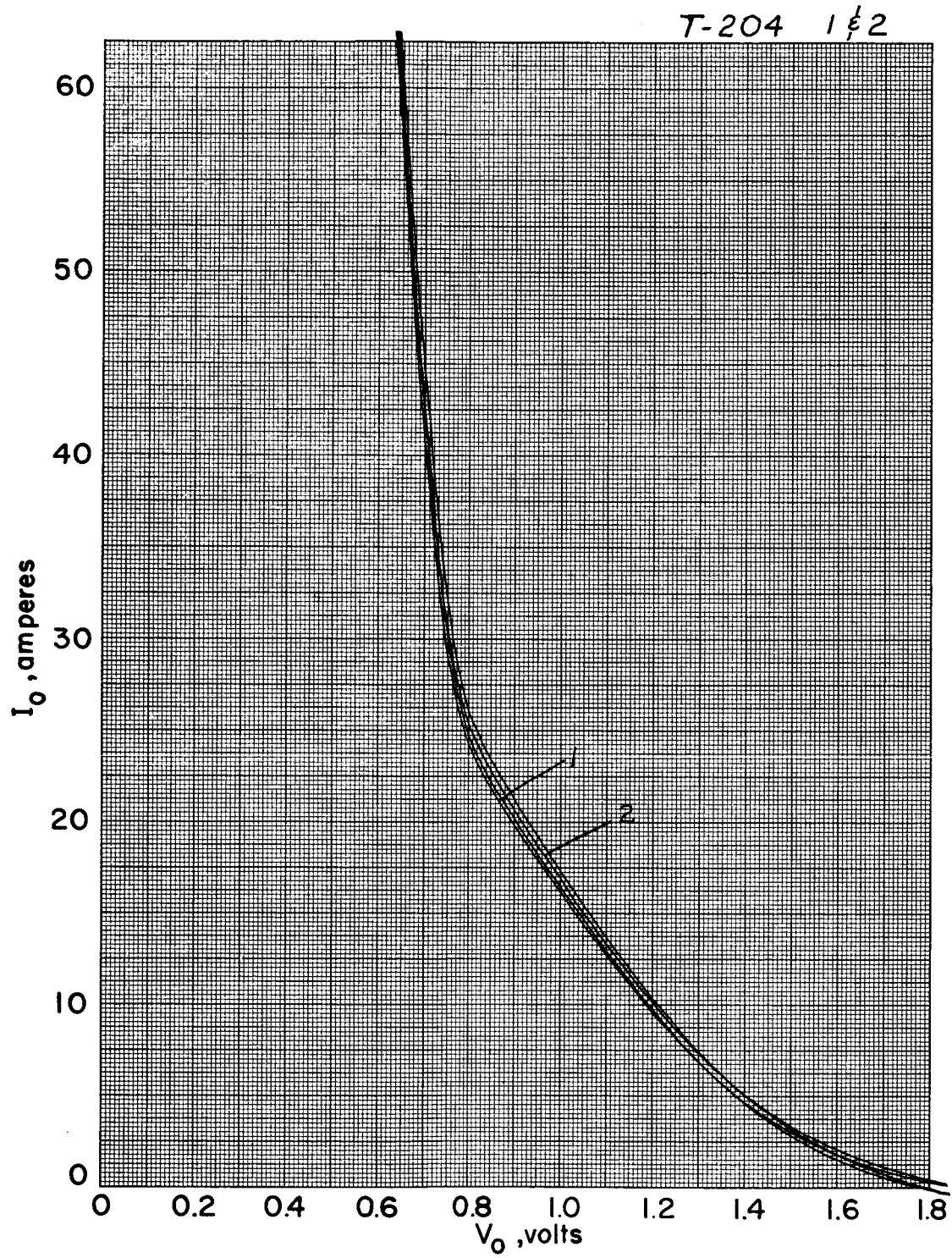


Converter No. TE-203B Run No. 7 Observer PB Slosek

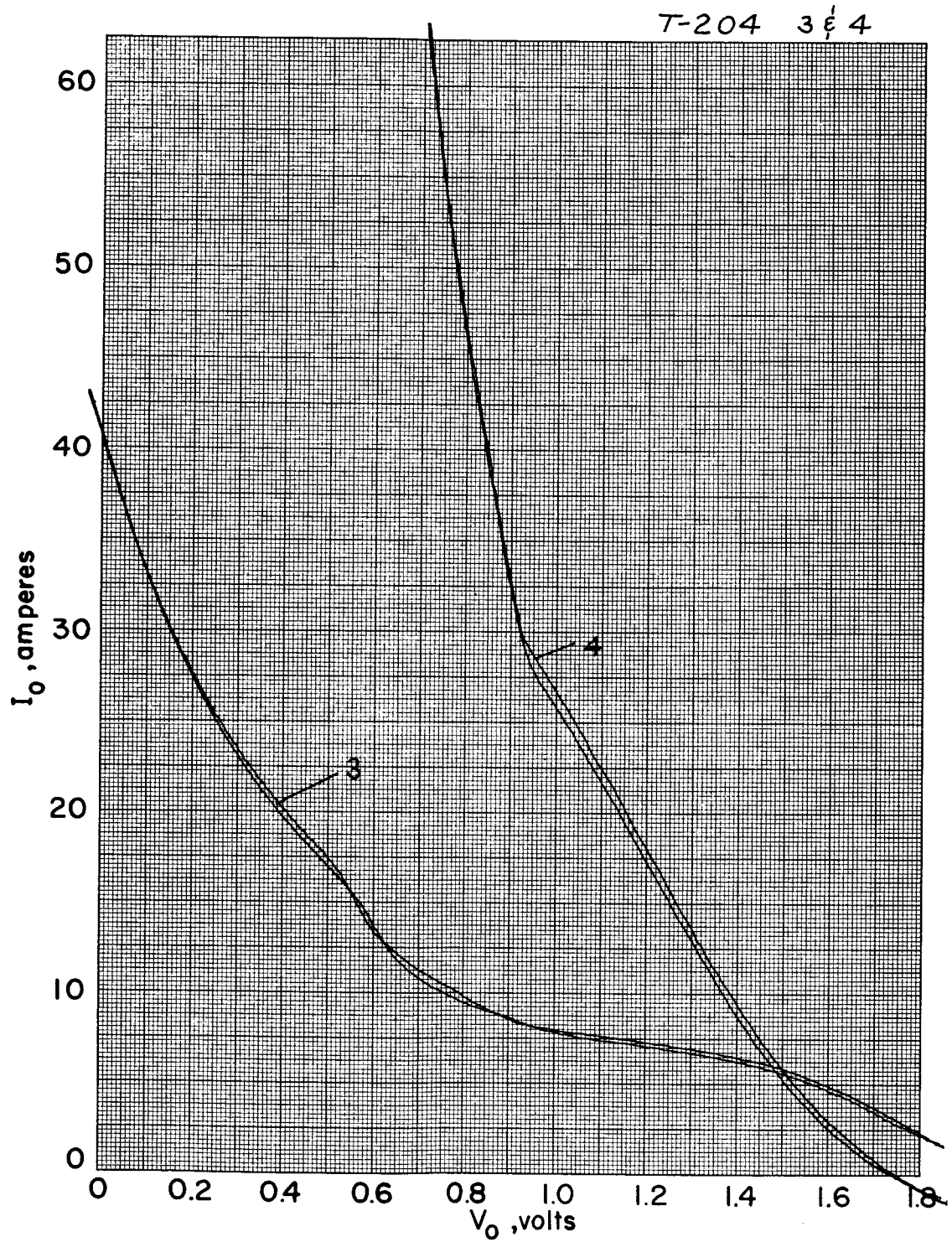
VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		7/7	-	-	7/8	-	-	-			
Time		1537	1622	1700	0920	0945	1000	1035			
Elapsed Time, Hours		-	-	-	-	-	-	-			
T _O , °C		1680	1680	1770	1770	1775	1775	1780			
T _O Corrected, °C		1690	1690	1780	1780	1785	1785	1719			
ΔT _{Bell Jar} , °C		14	14	14	14	14	14	14			
T _H , °C		1704	1704	1796	1796	1800	1800	1806			
ΔT _E , °C											
T _E , °K		1969	1969	2053	2055	2063	2063	2072			
V _O , volts		1.20	1.35 ^H	1.6379	1.8057	1.00	1.199	1.354			
I _O , amps		12.2	2.4	59.0	44.9	28.6	21.0	15.9			
P _O , watts		14.6	10.03	32.6	36.2	28.6	25.2	21.5			
I-V Trace No.		-	-	-	-	-	-	-			
T _R	mv	13.9	13.9	14.1	14.0	13.9	13.9	13.9			
	°C	341	341	345	343	341	341	341			
	°K	614	614	618	616	614	614	614			
T _C	mv	5-125	5-076	5-612	5-486	5-339	5-262	5-220			
	°C	562	538	806	743	670	631	610			
	°K	835	811	1079	1016	943	904	883			
T _C base inner	mv	20.7	20.0	22.4	26.0	23.9	22.9	22.0			
	°C	501	485	659	635	576	553	532			
T _C base outer	mv	20.9	19.9	27.3	25.9	23.9	22.9	21.9			
	°C	506	483	656	623	576	553	529			
T _{Radiator}	mv	19.9	18.0	22.3	22.3	20.9	20.0	19.9			
	°C	459	438	562	539	506	485	483			
V _{eb} , volts		985	987	965	968	973	978	979			
I _{eb} , mA		216	200.6	374	344	300	278	264			
E _{Filament} , volts		4.6	4.6	5.8	5.0	4.9	4.8	4.8			
I _{Filament} , amps		18.0	18.0	19.5	19.0	19.0	18.7	18.8			
I _{Coll. Heater} , amps		0	0	0	0	0	0	0			
I _{Res. Heater} , amps		2.0	3.0	3.0	3.0	3.0	3.0	3.0			
Vacuum, 10 ⁻⁶ mm Hg		.10	.10	.10	.094	.094	.094	.094			
Measured Efficiency, %											

NOTES: 1. Highest V_O possible.

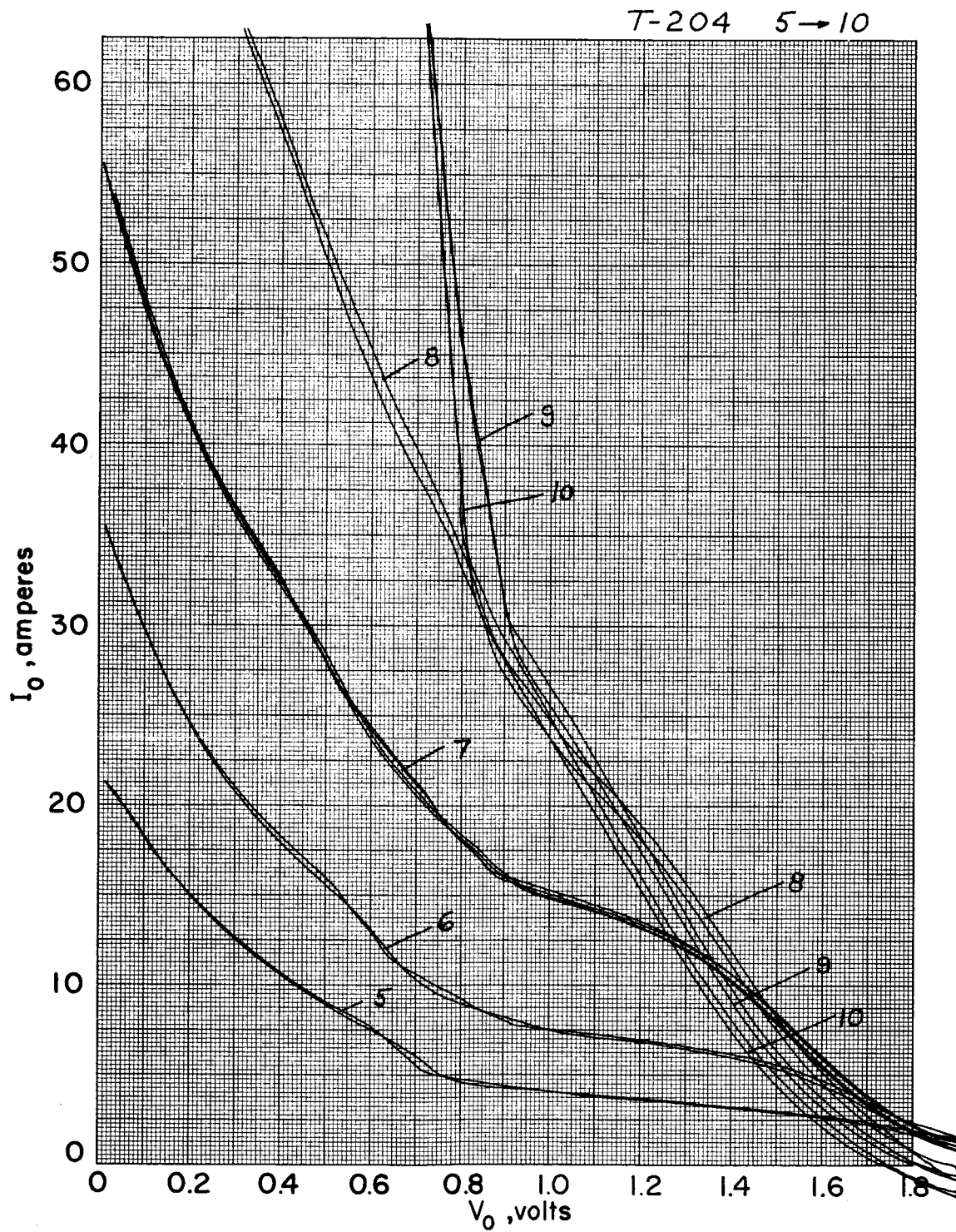
7434



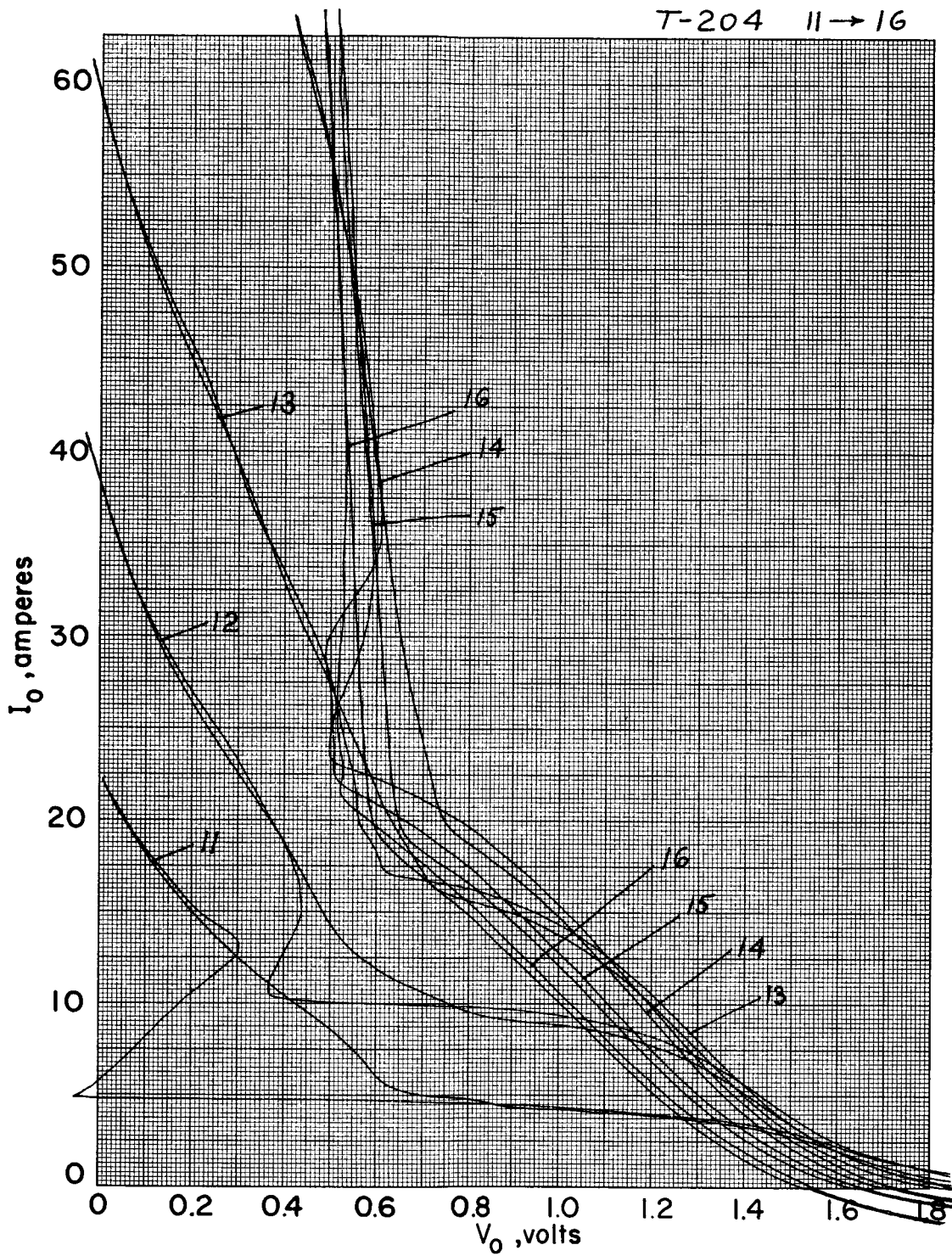
7435



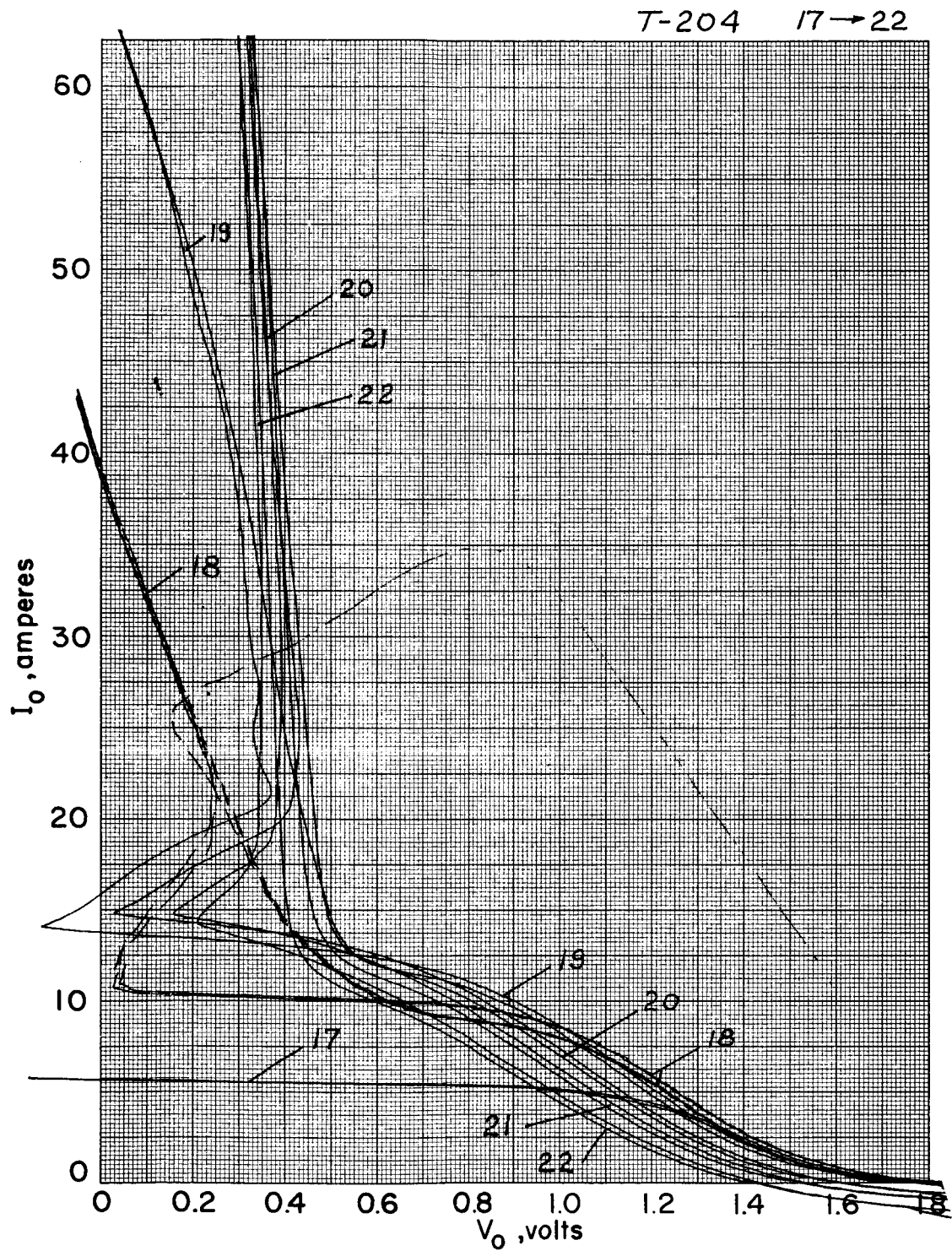
7437



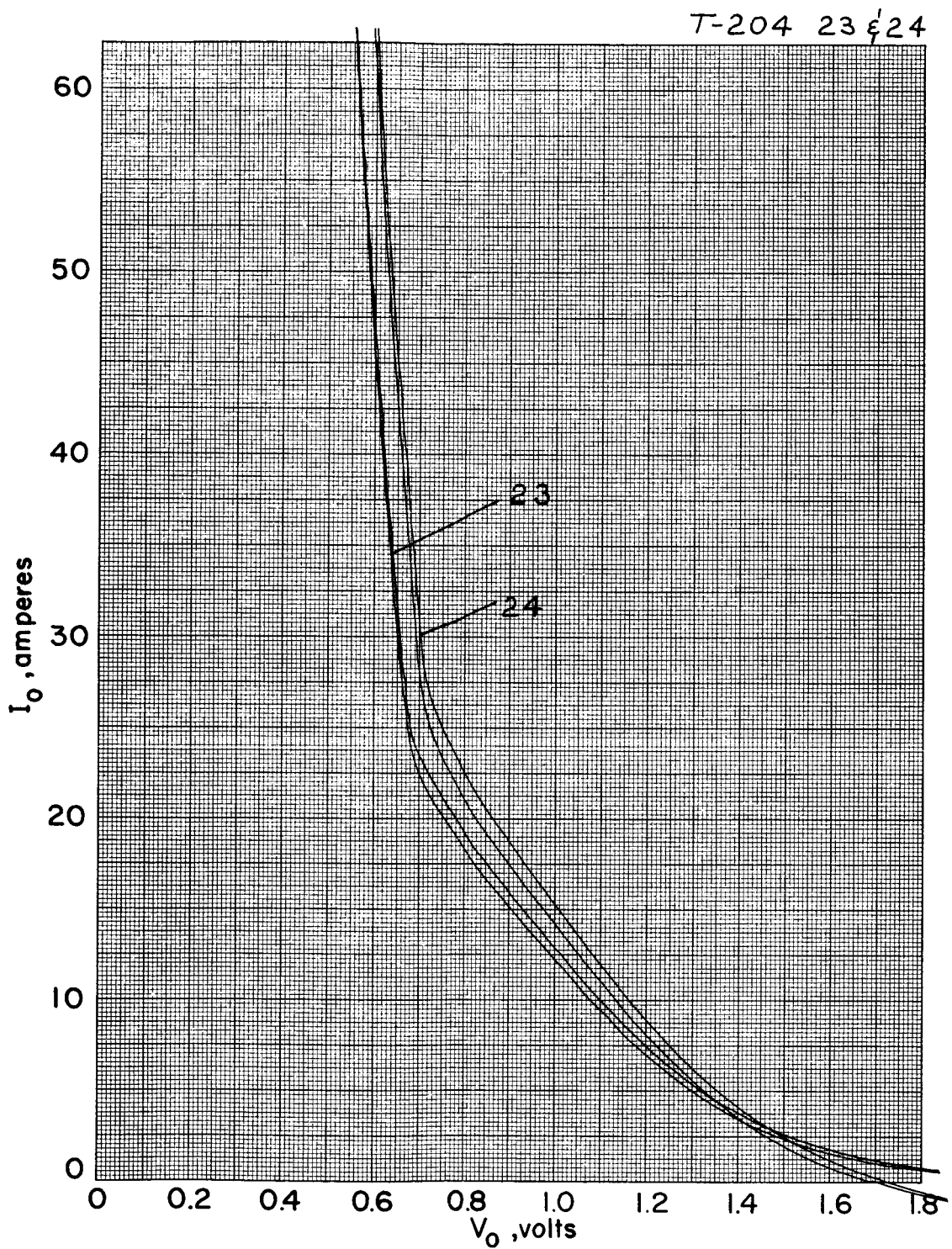
7436



7432



7433





Converter No. T-204 Run No. 1, 2 + 3 Observer R.B. Slosek

VARIABLE	1	2	3	4	5	6	7	8	9	10
Date	8/22	—	—	—	—	—	8/23	—	8/24	—
Time	1300	1325	1400	1440	1535	1650	0845	1610	0837	1625
Elapsed Time, Hours	—	—	—	—	0 ¹²	1.2	17.1	24.5	41.0	48.8
T ₀ , °C	1710	1710	1720	1710	1710	1720	1720	1710	1710	1720
T ₀ Corrected, °C	1720	1720	1730	1720	1720	1730	1730	1720	1720	1730
ΔT _{Bell Jar} , °C	14	14	14	14	14	14	14	14	14	14
T _H , °C	1734	1734	1744	1734	1734	1744	1744	1734	1734	1744
ΔT _E , °C										
T _E , °K	1976	1976	1992	1976	1970	1974	1974	1970	1970	1974
V ₀ , volts	1.31	1.23	1.06	1.24	.9023	.7731	.7839	.7834	.7839	.7691
I ₀ , amps	22.6a	23.0a	15.0a	24.0a	39.9	40.6	39.1	38.1	38.9	41.4
P ₀ , watts	—	—	—	—	36	31.2	30.7	29.8	30.5	31.8
I-V Trace No.	1	2	3	4	—	—	—	—	—	—
T _R	mv	0-814	0-814	0-520	0-700	0-700	0-700	0-700	0-700	0-700
		16.5	16.5	11.9	14.2	14.2	14.1	14.2	14.0	14.0
	°C	402	402	292	348	348	345	348	343	343
T _C	°K	675	675	565	621	621	688	621	616	616
	mv	2-486	2-538	2-332	2-532	2-638	2-598	2-591	2-575	2-575
	°C	743	769	666	966	819	799	795	787	787
T _C base inner	°K	1016	1042	939	1039	1092	1072	1068	1060	1060
	mv	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—
T _C base outer	mv	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—
T _{Radiator}	mv	21.4	22.0	20.2	22.3	22.9	22.3	22.2	22.0	22.0
	°C	518	532	489	539	553	539	537	532	532
	°K	541	541	541	541	541	541	541	541	541
V _{eb} , volts	977	977	985	978	967	971	969	967	970	969
I _{eb} , mA	292	296	229	284	357	330	325	323	325	334
E _{Filament} , volts	4.8	4.8	4.6	4.8	5.0	4.9	4.9	4.9	4.9	4.9
I _{Filament} , amps	18	18.2	18	18.1	19	19	18.9	18.5	18.7	18.7
I _{Coll. Heater} , amps	—	2	6	6.5	0	0	0	0	0	0
I _{Res. Heater} , amps	4	4	2	2	2	2	2	2	2	2
Vacuum, 10 ⁻⁶ mm Hg	.54	.8	.26	.28	.3	.23	.14	.14	.14	.12
Measured Efficiency, %										

NOTES: 1. Lowest Temp. Possible
2. Timer Set.
3. ?



Converter No. T-204 Run No. 344 Observer R. B. Slosek

VARIABLE	1	2	3	4	5	6	7	8	9	10
Date	8/25	—	8/26	—	8/29	—	—	—	—	—
Time	0850	1610	0952	1612	0920	1340	1420	1432	1450	1525
Elapsed Time, Hours	65.2	72.5	90.2	96.5	161.6	162.5	163.2	163.5	163.7	164.2
T _O , °C	1710	1710	1710	1710	1710	1710	1710	1720	1715	1720
T _O Corrected, °C	1720	1720	1720	1720	1720	1720	1720	1730	1725	1730
ΔT _{Bell Jar} , °C	14	14	14	14	14	14	14	14	14	14
T _H , °C	1734	1734	1734	1734	1734	1734	1734	1744	1739	1744
ΔT _E , °C										
T _E , °K	1966	1966	1966	1966	1966	1984	1982	1990	1985	1990
V _O , volts	.7691	.7685	.7679	.7765	.7783	1.263	1.155	1.109	1.175	1.314
I _O , amps	39.1	39.9	39.9	38.3	38.3	6.6a	11.9a	20.1a	24.5a	22.9a
P _O , watts	30	30.7	30.6	29.7	29.8	—	—	—	—	—
I-V Trace No.	—	—	—	—	—	5	6	7	8	9
T _R	mv	67.60 14.2	67.00 14.1	67.00 14.2	67.00 14.1	67.00 14.1	67.00 11.1	67.00 11.9	67.00 12.6	67.00 13.2
	°C	348	345	348	345	345	273	292	309	324
	°K	621	618	621	618	618	546	565	582	597
T _C	mv	2-575	2-575	2-575	2-575	2-575 ¹¹	2-194	2-254	2-320	2-400
	°C	787	787	787	787	787	597	627	660	700
	°K	106	1060	1060	1060	1060	870	900	933	973
T _C base inner	mv	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—
T _C base outer	mv	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—
T _{Radiator}	mv	22.3	22.3	22.2	22.1	22.0	19.5	20.1	20.2	20.9
	°C	539	539	537	534	532	473	487	489	506
V _{eb} , volts		969	969	968	969	969	989	985	981	978
I _{eb} , mA		323	327	323	323	323	194	210	242	266
E _{Filament} , volts		4.9	4.9	4.9	4.9	4.9	4.6	4.6	4.6	4.7
I _{Filament} , amps		18.9	18.9	18.5	18.5	18.5	17.5	17.7	18	18
I _{Coll. Heater} , amps		0	0	0	0	0	8	8	5	5
I _{Res. Heater} , amps		2	2	2	2	2	2	2	3	3
Vacuum, 10 ⁻⁶ mm Hg		.1	.1	.1	.1	.095	2.4	1.2	1.1	1.0
Measured Efficiency, %										

NOTES: 1. Cooling strap on fin and Rex.



Converter No.

T-204Run No. 4

Observer

R.B. Slosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		8/29	—	—	—	—	—	—	8/30	—	—
Time		1548	1615	1630	1645	1700	1712	1725	0915	0935	0955
Elapsed Time, Hours		164.6	165.1	165.3	165.6	165.8	166.0	166.2	182.1	182.4	182.8
T_0 , °C		1730	1610	1615	1615	1620	1605	1610	1520	1525	1525
T_0 Corrected, °C		1740	1619	1624	1624	1629	1614	1619	1529	1534	1534
$\Delta T_{\text{Bell Jar}}$, °C		14	12	12	12	12	12	12	12	12	12
T_H , °C		1754	1631	1636	1636	1651	1625	1631	1539	1544	1544
ΔT_E , °C											
T_E , °K		1996	1880	1892	1884	1884	1868	1864	1792	1794	1786
V_0 , volts		1.251	1.219	1.079	1.020	1.152	1.129	1.049	1.049	1.039	.9615
I_0 , amps		23.7a	6.9a	12.9a	21.9a	21.9a	21.9a	22.9a	2.9a	13.9a	21a
P_0 , watts		—	—	—	—	—	—	—	—	—	—
I-V Trace No.		10	11	12	13	14	15	16	17	18	19
T_R	mv	0-744 14.9	0-542 10.9	0-680 11.9	0-620 12.3	0-658 13.0	0-700 13.9	0-744 14.9	0-542 10.9	0-580 11.9	0-620 12.9
	°C	364	268	292	302	319	341	364	268	292	317
	°K	637	541	565	575	592	614	637	541	565	590
T_C	mv	2-578	2-194	2-254	2-320	2-400	2-448	2-518	2-194	2-254	2-320
	°C	759	597	627	660	700	724	759	597	627	660
	°K	1032	870	900	933	973	997	1032	870	900	933
T_C base inner	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T_C base outer	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T_{Radiator}	mv	22.1	19.9	19.9	20.4	21.1	21.9	22.9	19.9	19.9	20.9
	°C	511	483	483	494	511	529	553	483	483	506
V_{eb} , volts		976	992	988	984	983	982	981	995	990	986
I_{eb} , mA		286	160	180	206	223	224	233	129	154	178
E_{Filament} , volts		4.7	4.4	4.4	4.6	4.6	4.6	4.6	4.3	4.4	4.4
I_{Filament} , amps		18	17	17	17.5	17.8	17.8	18	17	17	17.1
$I_{\text{Coll. Heater}}$, amps		7	9.5	9.0	6	8	9	10.5	11	10	10
$I_{\text{Res. Heater}}$, amps		4	2	2.5	2.5	2.5	4	4.5	1	2	2
Vacuum, 10^{-6} mm Hg		.84	.52	.52	.44	.44	.46	.54	.12	.14	.14
Measured Efficiency, %											

NOTES:



Converter No. T-204 Run No. 4,5+6 Observer R.B. Slosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		8/30	—	—	—	—	— ^U	—	—		
Time		1015	1040	1115	1350	1400	1430	1450	1530	1550	1610
Elapsed Time, Hours		183.1	183.5	184.1	185.4	185.7	186.1	186.5	187.2	187.5	187.8
T _O , °C		1520	1525	1530	1710	1710	1716	1720	1720	1720	1720
T _O Corrected, °C		1529	1534	1539	1720	1720	1725	1730	1730	1730	1730
ΔT _{Bell Jar} , °C		12	12	12	14	14	14	14	14	14	14
T _H , °C		1539	1544	1548	1734	1734	1739	1744	1744	1744	1744
ΔT _E , °C											
T _E , °K		1782	1786	1792	1976	1976		1997	1997	1997	1997
V _O , volts		1.000	.9769	.9311	1.514	1.235	—	0	0	0	0
I _O , amps		21.0 _{an}	21.4 _{an}	21.0 _{an}	21.3 _{an}	26.0 _{an}	—	0	0	0	0
P _O , watts		—	—	—	—	—	—	0	0	0	0
I-V Trace No.		20	21	22	23	24	—	—	—	—	—
T _R	mv	0-658 13.2	0-200 13.9	0-744 14.9	0-814 16.3	0-814 16.4	10.mv.	10	11	12	13
	°C	324	341	364	398	400	246	246	271	295	319
	°K	597	614	637	671	673	519	519	544	568	592
T _C	mv	2-400	2-448	2-518	2-376	2-538	2-254	2-254	2-254	2-254	2-254
	°C	700	724	759	688	769	627	627	627	627	627
	°K	973	997	1032	961	1042	900	900	900	900	900
T _C base inner	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T _C base outer	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T _{Radiator}	mv	21.9	21.9	23	19.9	22.2	20.1	20.3	20.3	20.2	20.3
	°C	529	529	555	483	537	487	492	492	489	492
V _{eb} , volts		985	984	984	979	975	983	990	989	989	988
I _{eb} , mA		186	191	196	226	289	187	185	189	194	200
E _{Filament} , volts		4.5	4.5	4.5	4.7	4.7	4.4	4.4	4.5	4.5	4.5
I _{Filament} , amps		12.5	12.5	12.5	18.0	18	17	17	17.1	17.2	17.4
I _{Coll. Heater} , amps		9.5	10.5	11	0	7	9	9	9	9	9
I _{Res. Heater} , amps		4	4	4	6	6	1	1	1	2	3.5
Vacuum, 10 ⁻⁶ mm Hg		.16	.17	1.0	1.0	1.0	.38	.32	.28	.26	.24
Measured Efficiency, %											

NOTES: 1. ?

Converter No. T-204Run No. 647Observer R.B. Stosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		9/30	—	8/31	—	9/1	—	—	—	—	9/2
Time		1640	1705	1025	1055	1605	1620	1630	1645	1658	0955
Elapsed Time, Hours		188.3	188.7	206	206.6	228.6	228.8	229.0	229.2	229.4	246.4
T_0 , °C		1710	1710	1705	1710	1790	1800	1810	1810	1815	1700
T_0 Corrected, °C		1720	1720	1715	1720	1800	1810	1820	1820	1825	1710
$\Delta T_{\text{Bell Jar}}$, °C		14	14	14	14	14	14	14	14	14	14
T_H , °C		1734	1734	1729	1734	1816	1826	1836	1836	1842	1724
ΔT_E , °C											
T_E , °K		1987	1987	1982	1987	2038	2050	2066	2074	2090	1946
V_0 , volts		0	0	0	0	6659	8014	1019	1203	1353	6022
I_0 , amps		0	0	0	0	67.9	58.7	45.4	34.6	26.5	56.1
P_0 , watts		0	0	0	0	45.2	47	46.3	41.6	35.9	33.8
I-V Trace No.		—	—	—	—	—	—	—	—	—	—
T_R	mv	14	15	16	16.9	15.9	15.5	14.9	14.9	14.4	14.9
	°C	343	367	391	412	388	379	364	364	353	364
	°K	616	640	664	685	661	652	637	637	626	637
T_C	mv	2-254	2-254	2-254	2-254	2-976	2-895	2-748	2-631	2-544	2-775
	°C	627	627	627	627	988	947	874	815	772	887
	°K	900	900	900	900	1261	1220	1147	1088	1045	1160
T_C base inner	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T_C base outer	mv	—	—	—	—	—	—	—	—	—	—
	°C	—	—	—	—	—	—	—	—	—	—
T_{Radiator}	mv	19.9	19.9	19.9	20.0	25.9	25.4	24.4	23.5	22.9	24.9
	°C	483	483	483	485	623	612	588	567	553	600
V_{eb} , volts		988	988	985	985	958	960	964	967	970	961
I_{eb} , mA		198	206	209	217	475	455	418	386	356	380
E_{Filament} , volts		4.5	4.5	4.5	4.5	5.2	5.1	5	4.9	4.8	5
I_{Filament} , amps		17.5	17.5	17.5	17.5	19	19	18.5	18.2	18	18.5
$I_{\text{Coll. Heater}}$, amps		8	8	6	6	0	0	0	0	0	0
$I_{\text{Res. Heater}}$, amps		5	5.2	5	5.5	4	4	3.5	4	4	4
Vacuum, 10^{-6} mm Hg		2.2	2.2	.12	.12	4.6	2.6	1.6	1.2	1.0	.22
Measured Efficiency, %											

NOTES:



Converter No. T-204 Run No. 7 Observer R.D. Sosek

VARIABLE		1	2	3	4	5	6	7	8	9	10
Date		9/2	—	—	—	—	—	—	—	—	
Time		1011	1035	1100	1115	1140	1315	1355	1430	1545	
Elapsed Time, Hours		246.7	242.1	247.5	247.7	248.2	249.7	250.4	251	252.3	
T_0 , °C		1700	1700	1700	1700	1600	1600	1600	1600	1600	
T_0 Corrected, °C		1710	1710	1710	1710	1609	1609	1609	1609	1609	
$\Delta T_{\text{Bell Jar}}$, °C		14	14	14	14	12	12	12	12	12	
T_H , °C		1724	1724	1724	1724	1620	1620	1620	1620	1620	
ΔT_E , °C											
T_E , °K		1954	1961	1970	1970	1858	1864	1866	1870	1870	
V_0 , volts		8010	1,000	1.201	1.356	.5991	.7999	1.000	1.200	1.354	
I_0 , amps		42.0	29.0	19.9	13.4	39.1	20.1	15.8	10.6	7.3	
P_0 , watts		33.6	29	23.9	18.2	23.4	16.1	15.8	12.7	9.9	
I-V Trace No.		—	—	—	—	—	—	—	—	—	
T_R	mv	14.3	13.9	13.9	13.4	13.5	13.2	13.1	13.0	12.4	
	°C	350	341	341	329	331	324	321	319	304	
	°K	623	614	614	602	604	597	594	592	577	
T_C	mv	2-612	2-459	2-353	2-271	2-501	2-280	2-223	2-154	2-093	
	°C	806	729	676	635	750	690	611	577	546	
	°K	1079	1002	949	908	1023	913	884	850	819	
T_C base inner	mv	—	—	—	—	—	—	—	—	—	
	°C	—	—	—	—	—	—	—	—	—	
T_C base outer	mv	—	—	—	—	—	—	—	—	—	
	°C	—	—	—	—	—	—	—	—	—	
T_{Radiator}	mv	23.4	21.9	20.9	20.1	22.1	20.1	19.4	18.9	18.1	
	°C	564	529	506	487	534	487	471	459	440	
V_{eb} , volts		966	971	975	978	972	978	981	985	986	
I_{eb} , mA		341	301	271	249	278	227	215	199	188	
E_{Filament} , volts		4.8	4.8	4.6	4.6	4.8	4.6	4.6	4.5	4.5	
I_{Filament} , amps		18	18	17.9	17.5	18	17.5	17.5	17.1	17.0	
$I_{\text{Coll. Heater}}$, amps		0	0	0	0	0	0	0	0	0	
$I_{\text{Res. Heater}}$, amps		4	4	4	4	4	4	4	4	4	
Vacuum, 10^{-6} mm Hg		.16	.12	.12	.10	.10	.1	.1	.1	.1	
Measured Efficiency, %											

NOTES:

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